TABLA PARA LOCALIZACION EXPEDITIVA DE FOCOS SISMICOS PROFUNDOS

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RESUMEN

Los métodos expeditivos dados para determinar la posición de focos sísmicos profundos y basados en datos de una sola estación no son aplicables cuando la distancia epicentral es pequeña. Considerando esta circunstancia, se propone un nuevo método exento de esa limitación, basado en el empleo de las fases P, S y ScS y en tablas calculadas al efecto, que se suministran.

Con frecuencia resulta necesario contar con un procedimiento expeditivo que permita determinar la posición de un foco sísmico profundo usando los datos de una sola estación. Treinta años atrás fue sugerido por Schon (1935) un procedimiento basado en las fases P, S, pP y sS. En esencia, el procedimiento se basaba en las expresiones como

$$\frac{pP + P}{2} - H \qquad \frac{sS + S}{2} - H$$

(donde H representa la hora de origen) que teóricamente son funciones de la distancia epicentral θ y de la profundidad h del foco sísmico que varían prácticamente sólo con θ.

De ello se sigue que se puede definir las fases ficticias

$$\sigma = \frac{sS + S}{2} ; \quad \pi = \frac{pP + P}{2}$$

con tiempos de recorrido dependientes en primera aproximación sólo de θ y por lo tanto, poner

$$\sigma = H + \sigma(\theta) ; \quad \pi = H + \pi(\theta) ; \quad \sigma - \pi = F(\theta)$$

Construyendo una tabla $F(\theta)$, bastaría entrar en ella con $\sigma - \pi$, para obtener θ. Como $F(\theta)$ se puede considerar independiente de h, debe elegirse un valor cualquiera de h para calcular esa función, valor que Schon recomienda igualar a cero.

Una vez determinado θ, se puede determinar h con este valor y con pP–P en base a una tabla que dé

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A TABLE FOR EXPEDITE LOCATION OF DEEP EARTHQUAKE FOCI

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ABSTRACT

The expedite methods so far known for the location of deep earthquake foci and based on data from a single station can not be applied when the epicentral distance is short. In view of this consideration, a new method free from such limitation, and based on P, S and ScS phases and in tables prepared for such purpose, is proposed.

It is frequently necessary to rely on an expedite procedure for the location of deep earthquake foci based on data from only one station. Thirty years ago one of such procedures based on phases P, S, pP and sS, was given by Schon (1935). Essentially, the procedure was based on such expression as

(where H represents the hour of origin) that are theoretically a function of epicentral distance θ, and of depth h of the seismic focus changing practically only with θ.

Fictitious phases are thus defined as

with running times depending only on first approximation of θ, so that we may write

By constructing a table $F(\theta)$, it will only be necessary to enter into it with $\sigma - \pi$ to obtain θ. Since $F(\theta)$ does not appreciably change with h, any value of h may be selected to calculate that function, a value that Schon recommended to be equal to zero.

Once θ is obtained, the value of h can be determined with that value and with pP–P on basis of a table that gives

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$$pP - P = f(\theta, h)$$

Finalmente, con la expresión

$$H = P - P(\theta, h)$$

o con la expresión

$$H = \pi - \pi(\theta)$$

se puede obtener H.

Otro procedimiento expeditivo fue señalado poco después por Gutenberg y Richter (1936). Estos autores reparan en que también p'p'–P y PKKP–P, que son funciones de θ y P–H considerada como función de (S–P), varían poco con h. Señalan, por lo tanto, la posibilidad de determinar θ usando la primera de esas diferencias, H en base de P–H = f(S–P) y luego h en base de θ y de p'p'–H o de PKKP–H.

El método de Schon adolece del inconveniente de que es difícil identificar pP y sS en focos cercanos. Además, sólo puede aplicarse para $\theta > 45°$ si la profundidad del foco es muy grande y en todo caso, para θ no menor de 25° si ésta es pequeña.

Algo parecido ocurre con el método de Gutenberg y Richter, porque p'p'–P empieza con valores de θ del orden de 40° y PKKP–P con valores de θ del orden de 95°.

Para sortear las dificultades y determinar la posición del foco sísmico en estaciones en que θ sea pequeño, queremos sugerir otro método basado en el empleo de la fase ScS conjuntamente con las fases P y S. Las tres fases se registran desde $\theta = 0$ en adelante y frecuentemente en focos profundos, no sólo se puede identificar bien P y S en el sismograma, sino también ScS, fase cuyo tiempo de recorrido varía pronunciadamente con h. Una idea de cómo aparece esa fase puede sacarse de las Figs. 1, 2, 3 y 4, correspondientes a registros obtenidos en La Plata.

Para las fases P, S y ScS pueden escribirse las ecuaciones:

Finally, with the expression $H = P - P(\theta, h)$ or with the expression $H = \pi - \pi(\theta)$ H may be obtained.

Shortly afterwards another expedite procedure was suggested by Gutenberg and Richter (1936). These authors noticed that p'p'–P and PKKP–P, which are functions of θ and P–H, considered as a function of (S–P) change also little with h. Therefore, they indicated the possibility of determining θ by using the first of such differences, H on basis of P–H = f(S–P) and then h on basis of θ and of p'p'–H or of PKKP–H.

Schon's method had the inconvenience that it is very difficult to identify pP and sS in nearby foci. Furthermore, if can only be applied for $\theta > 45°$ if depth of focus is very great, and in all cases for θ not inferior of 25° if it is too small.

Something similar happens with the method of Gutenberg and Richter because p'p'–P begins with values of θ of the order of 40° and of PKKP–P with values of θ of the order of 95°.

To prevent such difficulties, and to determine the position of the seismic focus in stations where θ is small, we want to suggest another method based on the employment of phase ScS in conjuction with phases P and S. The three phases are registred since $\theta = 0$ forwards, and frequently in deep foci, where not only P and S can be identified in the seismogram but also ScS, a phase whose running time changes very much with h. An idea of how this phase is manifested may be obtained from Figs. 1, 2, 3 and 4, corresponding to records obtained at La Plata.

For phases P, S and ScS the equations may be written as

$$\begin{aligned} P - H &+ f_1 (\theta, h) \\ S - H &+ f_2 (\theta, h) \\ ScS - H &+ f_3 (\theta, h) \end{aligned} \tag{1}$$

en las cuales entran las incógnitas H, θ y h. Se tienen, en consecuencia, tantas ecuaciones como incógnitas. Siguiendo normas clásicas para resolver ecuaciones como la Ec. (1) podría emplearse el siguiente procedimiento.

Se empieza por restar miembro a miembro esas ecuaciones. Con ello se elimina H y se obtiene:

in which the unknowns H, θ and h are included. Thus, there are as many unknowns as equations. By adopting classical solutions to solve equations such as Eq. (1), the following procedure can be adopted.

First we substract member to member these equations, eliminating H and obtaining:

$$S - P = f_2 (\theta, h) - f_1 (\theta, h) = f_{21} (\theta, h) \tag{2}$$

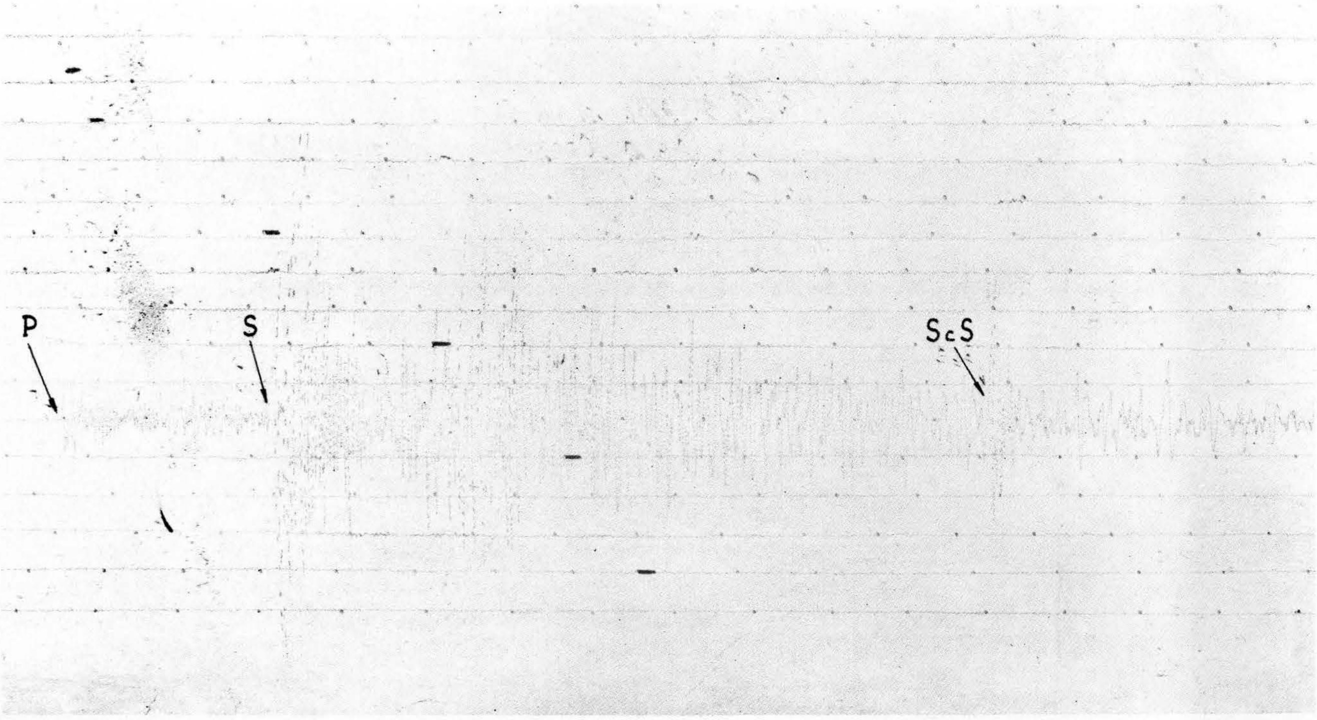
$$ScS - P = f_3 (\theta, h) - f_1 (\theta, h) = f_{31} (\theta, h) \tag{3}$$

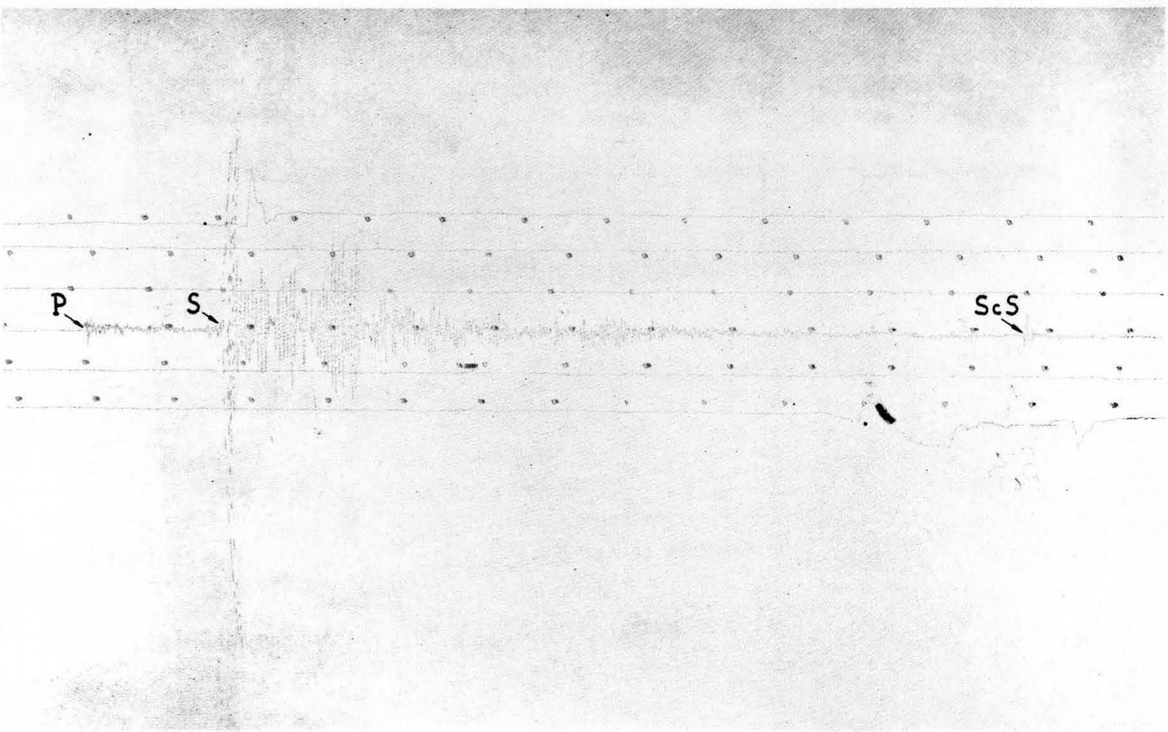
Desarrollando los segundos miembros en serie de Taylor a partir de valores aproximados θ_0 y h_0, resulta

By developing the second members in Taylor's series starting with approximate values θ_0 and h_0, it follows that

Fig. 1—Terremoto del 20 de Septiembre de 1952; Earthquake of September 20, 1952
φ = 22°5 S; λ = 65° W; H = 02h 30m 30seg.
θ' = 13°.83 h' = 250 Km
Sismogr.—Seismogr. MAINKA Vo = 170 To = 8s.3

Fig. 2—Terremoto del 4 de Mayo de 1953; Earthquake of May 4, 1953
φ = 28° S; λ = 62°5 W; H = 15h 26m 30seg.
θ' = 7°.92 h' = 600 Km
Sismogr.—Seismogr. MAINKA. Vo = 168 To = 8s.3


P
S
ScS


P
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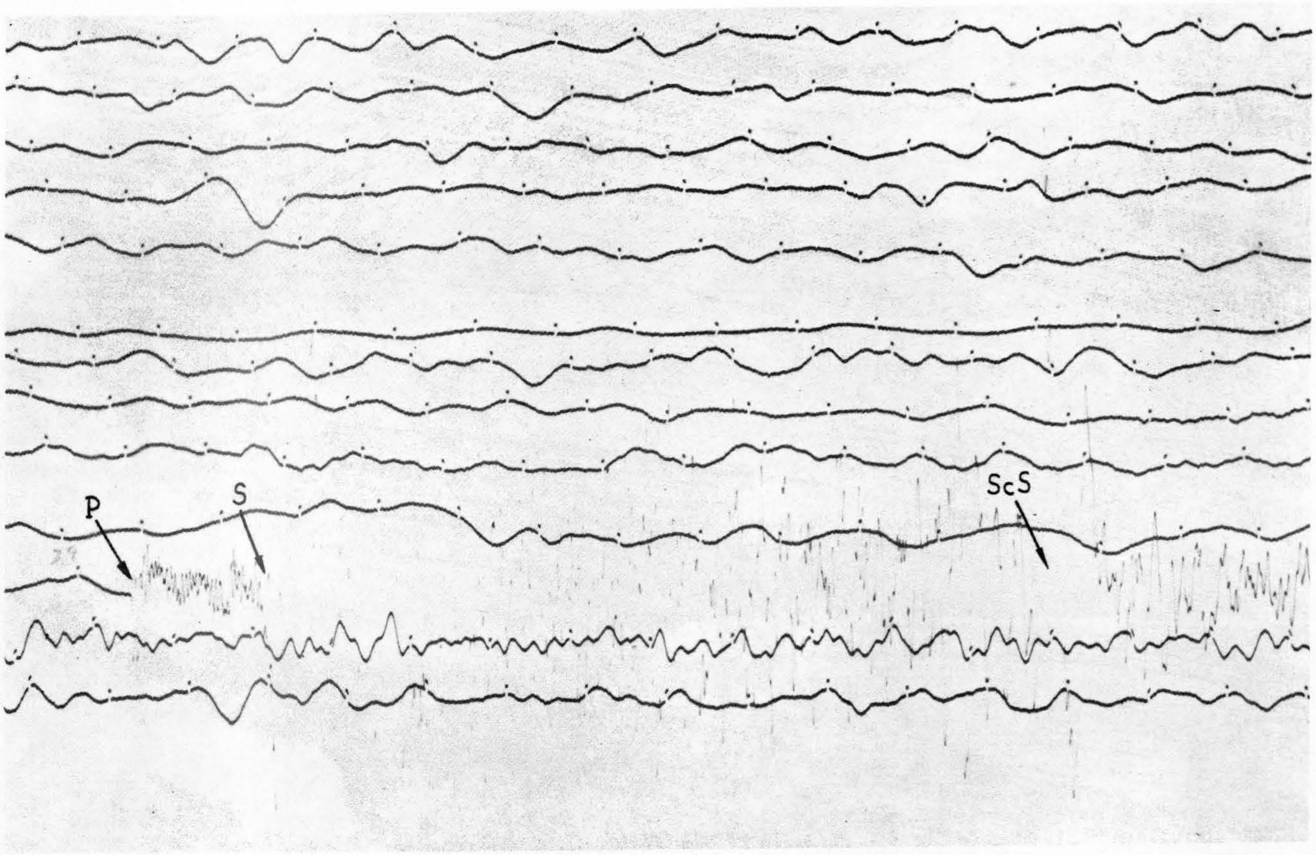
ScS


P
S
ScS


P
S
ScS

Fig. 3—Terremoto del 8 de Diciembrfe de 1962; Earthquake of December 8, 1962
φ = 25°.8 S; λ = 63°.4 W; H = 27h 27m 22.2seg.
θ' = 10°.20 h' = 620 Km
Sismogr.—Seismogr. L. P. "VELA" To = 30seg. Amp. = 750

Fig. 4—Terremoto del 9 de Diciembre de 1964; Earthquake of December 9, 1964
φ = 27°5 S; λ = 63°.2 W; H = 13h 35m 42.4seg.
θ' = 8°.65 h' = 586 Km
Sismogr.—Seismogr. MAINKA Vo = 151 To = 8ˢ.0

$$S - P = f_{21}(\theta_0, h_0) = \left(\frac{\partial f_{21}}{\partial \theta}\right)_{0,0} \delta\theta + \left(\frac{\partial f_{21}}{\partial h}\right)_{0,0} \delta h + \ldots$$

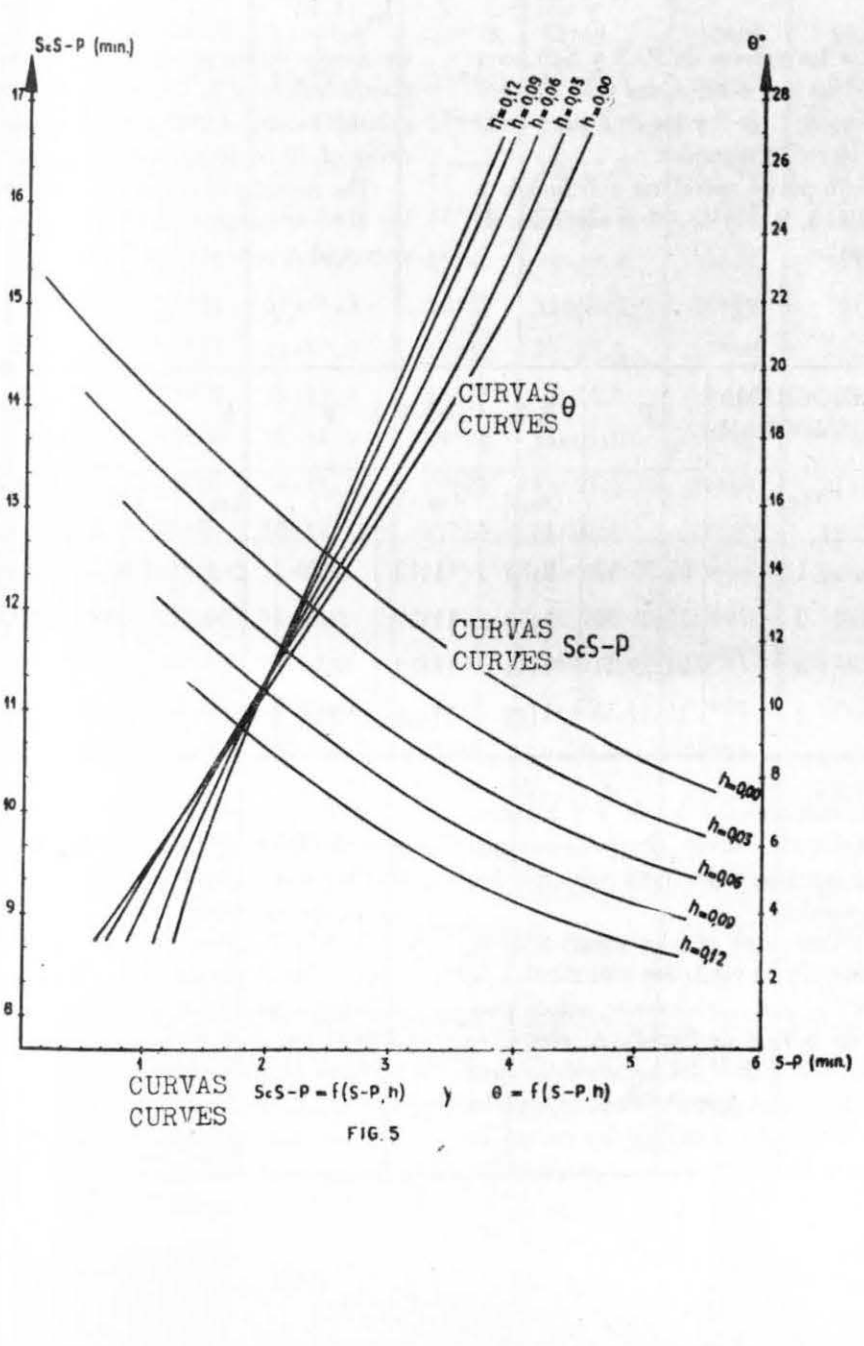
$$ScS - P = f_{31}(\theta_0, h_0) = \left(\frac{\partial f_{31}}{\partial \theta}\right)_{0,0} \delta\theta + \left(\frac{\partial f_{31}}{\partial h}\right)_{0,0} \delta h + \ldots \quad (4)$$

ecuaciones de las que se puede sacar $\delta\theta$ y δh, ya que se conocen los coeficientes de esas incógnitas y el valor de los primeros términos del 2º miembro. Dichos elementos se pueden extraer de las tablas de tiempos de recorrido; los primeros términos en base de los valores de f_1, f_2, f_3 para θ_0 y h_0, y los coeficientes por derivación numérica de esas funciones.

Hallados $\delta\theta$ y δh sería cuestión de repetir el cálculo, pero poniendo en (4) $\theta_0 + \delta\theta$ y $h_0 + \delta h$ en vez de θ_0 y h_0 y así siguiendo hasta que el primer miembro llegue a ser del orden de precisión con que se establece S–P y ScS–P. Pero, este procedimiento precisa conocer valores aproximados θ_0, h_0 de las incógnitas θ y h y además, es un poco pesado en su

equations from which $\delta\theta$ and δh may be extract since the ratios of these unknowns and the value of the first term of the 2nd. member are known. Those elements can be extracted from the running time tables; the first terms on bases of values of f_1, f_2, f_3 for θ_0 and h_0, and the ratios by numerical derivation of such functions.

When $\delta\theta$ and δh are found, it would be necessary to repeat the calculation, by introducing in (4) $\theta_0 + \delta\theta$ and $h_0 + \delta h$ instead of θ_0 and h_0, and thus following until the first member comes to be of the order of precission as that of S–P and ScS–P. But, this procedure needs to have approximate values θ_0, h_0 of the unknowns θ and h and is



CURVAS ScS-P = f(S-P, h) y θ = f(S-P, h)
CURVES

FIG. 5

realización. Para aliviar el trabajo notemos que teóricamente podríamos sacar θ de la ecuación (2) y poner:

furthermore a little bit difficult to execute. To alleviate the work, let us note that theoretically we could obtain θ from equation (2), and write:

$$\theta = \varphi\ (S - P, h) \qquad (5)$$

Consecuentemente, por substitución en (3) sacamos

Consequently, by substituting in (3) we obtain

$$ScS - P = \psi\ (S - P, h) \qquad (6)$$

Las ecuaciones (5) y (6) muestran que se puede construir una tabla para diversos h que de ScS–P y θ como función de S–P. Contándose con una tabla así, el valor de θ y de h se podría obtener fácilmente entrando en ella con los datos S–P y ScS–P del terremoto de que se trate.

Considerando esa posibilidad calculamos la Tabla I. En ella se dan esos valores para distancias epicentrales hasta unos 40°. Para formarla usamos las tablas de Jeffreys-Bullen (1940). Empezamos en tal sentido por obtener de esas tablas

Equations (5) and (6) show that it is feasible to construct a table for different h giving ScS–P and θ as functions of S–P. Having such a table, the values of θ and h could be easily obtained by entering into it with S–P and ScS–P data of the earthquake in study.

With that possibility in mind, we have calculated Table I, where such values are given for epicentral distances up to 40°. In order to construct it we used the tables of Jeffreys-Bullen (1940). We began in that sense by obtaining from those tables.

$$S - P = f_{21}\ (\theta, h)$$

$$\text{y and } ScS - P = f_{31}\ (\theta, h)$$

por simple diferencia entre los valores de P, S y ScS para los diversos valores de θ. Una vez conseguidas esas diferencias interpolamos los valores de ScS–P y los de θ para valores de S–P ordenados de 10 en 10 segundos.

La capacidad del método puede apreciarse aplicándolo a los sismogramas de las Figs. 1, 2, 3 y 4. Así se sacan los siguientes datos y resultados:

by simple difference between values of P, S and ScS for diverse values of θ. When we had such differences we interpolated values of ScS–P and θ for values of S–P in the order of 10 to 10 seconds.

The capacity of the method may be appreciated by applying it to seismograms of Figs. 1, 2, 3 and 4. The following data and results were obtained

TABLA I — TABLE I

SISMOGRAMA SEISMOGRAM	P	S–P	ScS–P	θ	h	θ'	h'
Fig.		(m:s)	(m:s)	(°)	(km)	(°)	(km)
1	02:33:52	2:33	11:42	13.76	262	13.83	250
2	15:28:36	1:38	11:37	8.36	580	7.92	600
3	21:29:41	1:44	11:19	8.97	650	10.20	620
4	13:37:48	1:42	11:35	8.89	568	8.65	586

Los valores θ' y h' corresponden a los de θ y h dados por el U. S. Coast and Geodetic Survey. Se puede ver que no hay una diferencia importante entre estos valores y los calculados con nuestro método.

Interesante es notar todavía que con los números de la Tabla I pueden constituirse curvas como las indicadas en la Fig. 5 que permiten apreciar muy rápidamente cuánto pueden ser θ y h en base de S–P y de ScS–P. Al efecto, se lee en las correspondientes a ScS–P el valor de h cuya abscisa es S–P y cuya ordenada es ScS–P. Luego, con dicho valor de h y de S–P se determina θ usando las curvas de este número.

The values of θ' and h' correspond to those of θ and h given by the U. S. Coast and Geodetic Survey. It may be seen that there is not an important difference between such values and those calculated by our method.

It is still interesting to note that curves may be constructed with numbers of Table I as indicated in Fig. 5, allowing a rapid estimate of amount of θ and h on basis of S–P and ScS–P. In effect, the value of h may be read in those corresponding to ScS–P, whose abcise is S–P and whose ordinate is ScS–P. Thus, with such values of h and S–P, we may determine θ by using the curves of that number.

	SUPERFICIE SURFACE		h = 0.00		h = 0.01		h = 0.02	
S-P	SoS - P	θ	SoS - P	θ	SoS - P	θ	SoS - P	θ
00:10.0	15:21.1	0°55	15:13.7	0°67				
00:20.0	15:08.4	1°45	15:00.1	1°63	14:45.6	1°52	14:32.2	1°01
00:30.0	14:55.8	2°35	14:47.6	2°53	14:32.7	2°53	14:19.6	2°24
00:40.0	14:43.5	3°25	14:35.2	3°43	14:20.3	3°45	14:06.9	3°29
00:50.0	14:31.2	4°15	14:23.0	4°33	14:08.5	4°36	13:54.8	4°27
01:00.0	14:19.2	5°05	14:11.0	5°23	13:56.9	5°27	13:42.9	5°24
01:10.0	14:07.3	5°96	13:59.2	6°14	13:45.3	6°19	13:31.5	6°18
01:20.0	13:55.4	6°88	13:47.4	7°06	13:33.4	7°13	13:20.0	7°13
01:30.0	13:43.7	7°79	13:35.9	7°97	13:22.1	8°05	13:08.5	8°08
01:40.0	13:32.3	8°70	13:24.6	8°88	13:11.1	8°96	12:57.5	9°03
01:50.0	13:21.3	9°61	13:13.5	9°80	13:00.0	9°91	12:46.7	9°98
02:00.0	13:10.2	10°54	13:02.4	10°73	12:49.1	10°85	12:35.9	10°94
02:10.0	12:58.9	11°46	12:51.6	11°66	12:38.5	11°79	12:25.2	11°91
02:20.0	12:48.9	12°39	12:41.1	12°59	12:27.9	12°74	12:14.9	12°87
02:30.0	12:38.5	13°32	12:30.9	13°52	12:17.8	13°69	12:05.0	13°83
02:40.0	12:28.4	14°25	12:20.9	14°46	12:08.0	14°63	11:55.0	14°81
02:50.0	12:18.4	15°20	12:10.9	15°41	11:58.2	15°60	11:45.4	15°79
03:00.0	12:08.5	16°15	12:01.3	16°37	11:48.8	16°57	11:36.2	16°78
03.10.0	11:59.1	17°12	11:52.0	17°33	11:39.4	17°57	11:27.5	17°76
03:20.0	11:49.9	18°09	11:42.7	18°31	11:30.8	18°54	11:19.8	18°76
03:30.0	11:41.0	19°06	11:34.2	19°27	11:23.2	19°53	11:11.6	19°91
03:40.0	11:33.2	20°01	11:27.1	20°21	11:15.5	20°63	11:03.9	21°08
03:50.0	11:26.3	21°00	11:19.5	21°33	11:07.9	21°82	10:56.1	22°35
04:00.0	11:18.8	22°16	11:12.1	22°51	11:00.2	23°08	10:48.3	23°70
04:10.0	11:11.3	23°39	11:04.5	23°77	10:52.6	24°42	10:40.9	25°06
04:20.0	11:03.7	24°71	10:57.9	25°13	10:45.2	25°81	10:33.9	26°45
04:30.0	10:56.4	26°08	10:49.7	26°53	10:38.3	27°21	10:27.3	27°87
04:40.0	10:49.7	27°47	10:42.9	27°94	10:32.1	28°57	10:21.1	29°31
04:50.0	10:43.2	28°89	10:36.9	29°36	10:25.8	30°07	10:15.1	30°77
05:00.0	10:37.2	30°33	10:30.9	30°81	10:20.3	31°51	10:09.9	32°21
05:10.0	10:31.5	31°78	10:25.3	32°26	10:15.0	32°97	10:05.0	33°65
05:20.0	10:26.2	33°24	10:20.3	33°71	10:10.1	34°42	10:00.4	35°10
05:30.0	10:21.2	34°70	10:15.5	35°16	10:05.6	35°87	09:56.2	36°56
05:40.0	10:16.8	36°13	10:11.3	36°60	10:01.5	37°33	09:52.1	38°03
05:50.0	10:12.7	37°58	10:07.1	38°06	09:57.8	38°79	09:48.4	39°52
06:00.0	10:08.8	39°06	10:03.5	39°52	09:54.1	40°29		
06:10.0	10:05.3	40°54						

	h = 0.03		h = 0.04		h = 0.05		h = 0.06	
S-P	ScS - P	θ	ScS - P	θ	ScS - P	θ	ScS - P	θ
00:10.0								
00:20.0								
00:30.0	14:05.8	1°79	13:52.7	0°71				
00:40.0	13:53.5	3°02	13:40.1	2°59	13:26.8	1°91		
00:50.0	13:41.3	4°10	13:26.9	3°93	13:15.0	3°42	13:01.9	2°84
01:00.0	13:29.5	5°12	13:16.1	4°93	13:03.0	4°66	12:49.9	4°30
01:10.0	13:17.8	6°12	13:04.6	5°98	12:51.4	5°80	12:38.5	5°56
01:20.0	13:06.4	7°10	12:53.3	7°01	12:40.1	6°89	12:27.3	6°70
01:30.0	12:55.1	8°08	12:41.9	8°03	12:28.9	7°95	12:16.1	7°82
01:40.0	12:43.8	9°07	12:31.0	9°04	12:18.1	8°99	12:05.3	8°91
01:50.0	12:33.0	10°05	12:20.3	10°04	12:07.5	10°02	11:54.8	9°99
02:00.0	12:22.1	11°05	12:09.8	11°04	11:57.7	11°06	11:44.5	11°06
02:10.0	12:11.7	12°02	11:59.4	12°05	11:46.7	12°10	11:35.0	12°10
02:20.0	12:01.9	12°99	11:49.3	13°06	11:36.8	13°13	11:25.4	13°21
02:30.0	11:52.0	13°97	11:39.4	14°08	11:27.7	14°14	11:16.4	14°31
02:40.0	11:42.2	14°97	11:29.9	15°10	11:19.1	15°21	11:07.7	15°44
02:50.0	11:33.0	15°96	11:21.7	16°08	11:10.1	16°36	10:59.2	16°60
03:00.0	11:24.3	16°95	11:13.1	17°19	11:01.5	17°52	10:50.6	17°81
03:10.0	11:16.3	17°98	11:04.9	18°34	10:53.4	18°70	10:42.0	19°08
03:20.0	11:08.5	19°11	10:56.8	19°52	10:45.1	19°95	10:33.7	20°41
03:30.0	11:00.2	20°32	10:48.7	20°78	10:36.9	21°28	10:25.6	21°78
03:40.0	10:52.3	21°58	10:40.6	22°11	10:29.1	22°64	10:18.2	23°14
03:50.0	10:44.3	22°92	10:32.9	23°74	10:21.8	24°01	10:11.1	24°55
04:00.0	10:36.8	24°28	10:25.9	24°85	10:14.9	25°42	10:04.3	25°97
04:10.0	10:29.6	25°69	10:18.9	26°28	10:08.1	26°87	09:57.8	27°42
04:20.0	10:22.8	27°10	10:12.2	27°72	10:01.8	28°32	09:51.8	28°87
04:30.0	10:16.5	28°53	10:06.2	29°16	09:56.0	29°76	09:46.1	30°32
04:40.0	10:10.6	29°97	09:59.8	30°61	09:50.7	31°19	09:41.0	31°77
04:50.0	10:05.0	31°41	09:55.1	32°06	09:45.7	32°64	09:36.2	33°22
05:00.0	09:59.8	32°87	09:50.3	33°51	09:40.9	34°10	09:31.6	34°69
05:10.0	09:55.2	34°31	09:45.6	34°96	09:36.5	35°56	09:27.4	36°18
05:20.0	09:50.8	35°77	09:41.5	36°43	09:32.6	37°04	09:23.6	37°67
05:30.0	09:46.7	37°24	09:37.5	37°91	09:28.8	38°55	09:20.2	39°18
05:40.0	09:42.8	38°73	09:34.1	39°39	09:25.3	40°06	09:16.7	40°72
05:50.0	09:39.4	40°23	09:30.5	40°92				

	h = 0.07		h = 0.08		h = 0.09		h = 0.10	
S–P	ScS – P	Θ	ScS – P	Θ	ScS – P	Θ	ScS – P	Θ
00:10.0	–							
00:20.0								
00:30.0								
00:40.0								
00:50.0	12:49.5	1°94						
01:00.0	12:37.8	3°79	12:25.5	3°14	12:14.0	2°11		
01:10.0	12:26.2	5°21	12:14.2	4°80	12:02.5	4°27	11:51.4	3°53
01:20.0	12:15.1	6°47	12:02.8	6°19	11:51.6	5°86	11:40.3	5°42
01:30.0	12:04.3	7°64	11:52.5	7°47	11:41.0	7°25	11:29.5	7°00
01:40.0	11:53.3	8°83	11:41.9	8°71	11:30.6	8°56	11:19.3	8°39
01:50.0	11:43.1	9°96	11:31.6	9°91	11:20.9	9°80	11:09.3	9°73
02:00.0	11:33.5	11°07	11:22.1	11°08	11:11.1	11°05	10:59.9	11°03
02:10.0	11:24.0	12°18	11:12.6	12°26	11:00.8	12°33	10:50.2	12°36
02:20.0	11:14.6	13°33	11:03.2	13°47	10:51.9	13°59	10:40.7	13°67
02:30.0	11:05.5	14°48	10:54.0	14°68	10:42.8	14°85	10:31.5	15°01
02:40.0	10:56.6	15°66	10:45.3	15°90	10:34.0	16°14	10:22.9	16°36
02:50.0	10:47.8	16°89	10:37.6	17°18	10:25.3	17°46	10:14.6	17°70
03:00.0	10:39.0	18°18	10:27.8	18°52	10:17.1	18°81	10:06.5	19°08
03:10.0	10:30.5	19°51	10:19.3	19°51	10:09.1	20°18	09:58.8	20°47
03:20.0	10:22.4	20°85	10:11.8	21°24	10:01.4	21°59	09:51.1	21°90
03:30.0	10:14.7	22°24	10:04.3	22°65	09:54.1	23°02	09:44.1	23°35
03:40.0	10:07.6	23°63	09:57.2	24°07	09:47.2	24°46	09:37.4	24°80
03:50.0	10:00.6	25°06	09:50.5	25°51	09:40.6	25°91	09:31.0	26°25
04:00.0	09:54.0	26°50	09:44.1	26°97	09:34.5	27°37	09:25.2	27°69
04:10.0	09:47.7	27°96	09:38.1	28°43	09:28.8	28°82	09:19.8	29°13
04:20.0	09:42.0	29°42	09:32.5	29°88	09:23.5	30°26	09:14.6	30°59
04:30.0	09:38.6	30°87	09:27.5	31°32	09:18.6	31°72	09:09.8	32°06
04:40.0	09:31.7	32°31	09:22.7	32°77	09:13.9	33°19	09:05.3	33°55
04:50.0	09:27.2	33°75	09:18.1	34°24	09:09.5	34°67	09:01.3	35°05
05:00.0	09:22.9	35°22	09:13.9	35°73	09:05.7	36°17	08:57.2	36°58
05:10.0	09:18.8	36°72	09:10.2	37°23	09:01.8	37°72	08:53.7	38°14
05:20.0	09:15.0	38°23	09:06.8	38°75	08:58.4	39°27	08:50.5	39°70
05:30.0	09:11.7	39°77	09:03.4	40°31	08:55.3	40°84		

	h = 0.11		h = 0.12	
S-P	SoS - P	Θ	SoS - P	Θ
00:10.0				
00:20.0				
00:30.0				
00:40.0				
00:50.0				
01:00.0				
01:10.0	11:40.4	2°42		
01:20.0	11:28.7	4°88	11:18.0	4°13
01:30.0	11:18.4	6°61	11:07.4	6°18
01:40.0	11:08.0	8°18	10:56.8	7°93
01:50.0	10:58.0	9°63	10:47.1	9°45
02:00.0	10:48.5	11°00	10:37.7	10°90
02:10.0	10:39.2	12°36	10:28.5	12°32
02:20.0	10:30.1	13°72	10:19.7	13°73
02:30.0	10:21.1	15°10	10:10.7	15°16
02:40.0	10:12.5	16°49	10:02.2	16°59
02:50.0	10:04.2	17°88	09:53.8	18°01
03:00.0	09:56.1	19°30	09:46.0	19°45
03:10.0	09:48.5	20°71	09:38.6	20°90
03:20.0	09:41.3	22°15	09:31.9	22°35
03:30.0	09:34.4	23°60	09:24.9	23°80
03:40.0	09:28.1	25°04	09:18.7	25°23
03:50.0	09:21.9	26°49	09:12.9	26°68
04:00.0	09:16.2	27°94	09:07.5	28°13
04:10.0	09:11.0	29°39	09:02.3	29°62
04:20.0	09:06.1	30°85	08:57.4	31°10
04:30.0	09:01.3	32°35	08:52.9	32°66
04:40.0	08:57.0	33°85	08:48.8	34°12
04:50.0	08:53.0	35°38	08:44.9	35°67
05:00.0	08:49.3	36°92	08:41.4	37°24
05:10.0	08:45.8	38°50	08:38.1	38°83
05:20.0	08:42.8	40°08	08:35.4	40°41

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