the belt of large negative gravity anomalies. However, shocks at depths of 70 to 100 km. are also frequent, and their epicenters are closer to the coast, or even inland. At 4° N. 99° E., on the northeast coast of Sumatra, is a shock with depth of 200 km. (No. 102, July 4, 1936).

The Sunda arc extends into the Nicobar and Andaman Islands; but the seismicity is distinctly lower here than off Sumatra, so that a search has been made for additional shocks (Table 13; *see also* the great shock of June 26, 1941, 11:52, probably near 11° N., 93° E.). The line of epicenters follows the islands, but those near 15° N. are rather farther west than might be expected, and further continuation of the line is doubtful. On the other hand, a line of shallow shocks, some of them large, extends just east of the meridian of 96°, from a point north of Sumatra, across the shallow sea and far into Burma.

THE TRANS-ASIATIC ZONE

GENERAL STATEMENT

The earthquakes of continental Asia present the only important exception to the rule that the principal seismicity of the globe is aligned along comparatively narrow belts. In eastern Asia is an area thousands of miles wide, with shocks of moderate to large magnitude along so many structures within it that on the scale of the world map they appear to be scattered at random.

This first impression is much modified on inspection of Figure 10. The structural lines shown are taken from Born (1933), Willis (1939), Arni (1939), Clapp (1940), Mushketov, (1936a; 1936b), and Wilser (1928). Additional epicenters are from Table 14, and a few from Table 15. The distribution of seismicity is by no means random, but is closely related to the major structures. There is greater activity, in number and in magnitude of shocks, than in other similarly complex continental areas.

The wide eastern area is roughly triangular, narrowing westward as the structures converge toward the Pamir plateau. From the Hindu Kush westward the zone spreads again through Baluchistan and Iran, then contracts and enters Europe through Asia Minor.

The zone as a whole is characterized by the only great shallow shocks, and the only shocks at intermediate depth, outside the Pacific belt. No shocks deeper than 300 km. have been found here.

The rather well-defined southern limit of the zone is the southern front of the Asiatic belt of Alpide structures; the shocks near this front will be discussed first.

THE ALPIDE BELT

The frontal structures of the Alpide belt in southern Asia are a series of mountain arcs, convex to the south (except the Burma arc, which is convex to the west). In spite of certain evident differences, these arcs are usually

TABLE 14.—*Concluded.*

Day	Time	Epicenter		Quality	Class
		Latitude, degrees	Longitude, degrees		
1927, March 15	21:48:35	38½ N.	97½ E.	B	c
1925, Dec. 7	08:34:30	37 N.	76½ E.	B	d
1930, July 13	19:27:17	38 N.	98½ E.	A	c
1928, March 31	00:29:47	38 N.	27 E.	A	c
1924, Sept. 16	02:36:00	39 N.	70½ E.	B	c
1929, May 18	06:37:51	40 N.	38 E.	A	c
1927, April 30	13:56:47	38½ N.	78 E.	C	d
1928, Nov. 6	13:42:35	40 N.	53½ E.	B	d
1923, April 29	09:34:35	40 N.	37 E.	C	c
1924, Sept. 13	14:34:05	40 N.	42 E.	B	c
1923, Dec. 28	22:24:52	39½ N.	68 E.	B	c
1924, July 6	18:31:49	40½ N.	73½ E.	B	c
1929, June 13	22:15:51	43 N.	66 E.	C	d
1930, June 17	20:07:22	43½ N.	102½ E.	C	d
1929, Sept. 4	22:24:57	43 N.	67 E.	B	d
1927, Sept. 23	13:54:20	42½ N.	84 E.	B	c
1924, July 12	15:12:34	40½ N.	73½ E.	B	c
1929, Feb. 10	17:20:16	44 N.	44 E.	B	d
1929, June 3	20:29:47	43 N.	67 E.	A	c
1927, June 26	11:20:48	44½ N.	34½ E.	A	c
1923, Sept. 14	12:57:31	48 N.	96 E.	B	c
1928, Nov. 23	04:23:30	47½ N.	30 E.	B	d
1922, Aug. 25	19:29:40	50 N.	91 E.	B	c
1937, July 31	20:38:44	34½ N.	115 E.	A	c
1937, Aug. 1	10:41:00	35 N.	116 E.	A	c
1934, June 13	22:10:20	20 N.	62½ E.	B	b
1934, June 23	05:19:53	33 N.	92½ E.	A	c
1934, Aug. 7	11:49:58	43 N.	87½ E.	B	d
1934, Dec. 15	01:57:37	31½ N.	39½ E.	A	b
1935, Jan. 3	01:50:26	30½ N.	88 E.	B	c
1935, Jan. 4	14:41:25	40½ N.	27½ E.	A	c
1935, March 5	22:15:57	30 N.	80 E.	B	d
1935, April 11	23:14:40	35 N.	52 E.	B	c
1935, May 13	19:53:38	20 N.	101 E.	B	c
1935, July 5	17:53:01	38 N.	67½ E.	A	c
1935, Nov. 1	16:22:01	20½ N.	103½ E.	B	c
1936, May 27	06:19:19	28½ N.	83½ E.	A	c
1937, Jan. 2	14:04:02	35 N.	25 E.	B	d
1936, June 14	17:01:30	37 N.	35½ E.	A	d
1936, June 30	19:26:06	33 N.	60 E.	C	d
1936, Sept. 21	11:41:33	41 N.	33 E.	A	d
1937, Dec. 25	09:55:55	57 N.	110 E.	B	c
1938, Feb. 14	02:54:16	40½ N.	53½ E.	A	c
1938, March 14	00:48:33	21½ N.	75½ E.	A	d
1938, Oct. 19	04:13:26	49 N.	90 E.	B	d
1939, Jan. 22	04:41:08	56 N.	130 E.	B	d
1939, May 26	09:40:35	53 N.	109 E.	B	d

ward, and connects at a sharp angle with the Himalayan arc. This angle is obviously a region of great crustal disturbance, which is expressed by high regional seismicity, comparable with that near the Pamir Plateau, round the analogous angle at the other end of the Himalayan arc.

Except for intermediate shocks, the Burma mountain arc appears to be almost completely nonseismic. Shallow shocks ascribed to it are shown, on revision of the instrumental data, to have originated on the north-south line east of the arc. This line, which follows some evident structures, passes southward through Pegu, and apparently extends nearly to Sumatra. In this, seismological evidence fails to support the common practice of running the Burma arc into the active arc of the Andaman Islands, thereby connecting the Asiatic structures and seismic belts with those of the East Indies. Notwithstanding, the Sunda arc may be an eastern member of the Alpide series.

The south front of the Himalayan arc has been the origin of many great shocks. That of 1897 originated near Shillong (Assam) in the outlying hills south of the Himalaya; and the large earthquakes of 1905 and 1934 (Table 5) had similarly placed epicenters farther west. The epicenter of the great shock of 1819, in the Runn of Cutch at about 24° N. 69° E., occupies an anomalous position. The association of the mountain arc on the coast of Oman with the arcs of the Alpide belt is an unsettled question; a shock of 1884 was destructive at and near Muskat (Sieberg, 1932a, p. 795).

The most westerly of the southern structural arcs of the Alpide belt extends from northern Syria through the Mediterranean south of Cyprus and Crete. The instrumentally determined epicenters mark this out very plainly as the southern limit of the active area. This arc is identical with the southern boundary of the region Neo-Europa as indicated on the well-known map by Stille (1924).

EASTERN AND CENTRAL ASIA

The eastern coast of continental Asia, from China to Manchuria, is fairly quiet, with an occasional large shock. There is a definite gap between the high activity of the Japanese and Philippine areas and the continental seismicity.

Strong shocks are often destructive in the western Chinese provinces of Szechuan and Yünnan. (*See also* Heim, 1934.) In the mountain ranges of Tibet are several epicenters. The Kuen Lun shock of 1937 (Table 5) was a great earthquake. In view of the fragmentary nature of the macroseismic information which reaches us from this remote region, it is fortunate that the instrumentally located epicenters are satisfactory. The single epicenter in the Altyn Tagh represents a well-observed shock on September 25, 1933.

In the Nan Shan and eastward shocks are frequent, and many other epicenters could have been added. The adjacent province of Kansu with two great shocks in Table 5 (1920, 1927) is one of the most frequently shaken parts of China. The history of destructive shocks allows us to extend the seismic belt eastward, at least far enough to include the valley of the Weiho, which enters the Huangho from the west near 34° N. 110° E. This has long been one of the most thickly settled areas in the world, so that merely destructive shocks with considerable loss of life might not prove high local seismicity. However, the reported effects are extreme; the earthquake of 1556 in this region is said to have taken 830,000 lives. If the earthquake history can be trusted, it suggests a deflection to the north rather than an eastward continuation of the active line. However, strong shocks have occurred more nearly to the east; the two large shocks of July 31 and August 1, 1937 were well recorded and are mapped near 35° N. 115° E. A little farther east, destructive shocks have occurred in Shantung (January 8, 1910).

North and west of this line is the stable area of the Gobi Desert, and beyond is the broad and not very sharply defined belt of activity bounding the Asiatic seismic zone on this side. The boundary belt extends across most of Asia, following the southern half of the belt of great depressions marked by Lake Baikal, Lake Balkash, the Aral and Caspian seas, and the Black Sea. The great stable area of northern Asia lies on the other side of it. There is not a very wide gap between the most northeasterly shocks of this group and those of the Arctic belt near the mouth of the Lena. If this gap were closed, there would exist a seismic belt completely surrounding the Eurasian mass by way of the Arctic, the North Atlantic, the Azores, the Mediterranean, the Black Sea and central Asia. The Asiatic boundary belt resembles the Arctic and Atlantic belts in the absence of deep shocks, but differs in greater seismicity, and in the greater magnitude of its largest shocks. Table 5 includes five great shocks with epicenters ranging from the Pamir Plateau toward Lake Baikal. The alignment of activity is not along the strike of the more evident surface structures of the region (Fig. 10) which are mostly Palaeozoic or older. Instead, the active belt follows the region of highlands between the great depressions and the Gobi Desert.

The structures associated with the Caucasus and the Crimean mountains are also active. (*See* Mushketov, 1936a). Between the Aral Sea and the Caspian, at 42.9° N. 56.5° E., the single well-located shock of July 14, 1933 shows that the boundary of the active zone must be drawn well toward the north, in line with the active east-west structures north and northwest of the Tien Shan.

MEDITERRANEAN EUROPE

Figure 2 shows that, if the shocks of a few decades were used solely, western Europe would hardly be included among the seismic regions of the

Italy, for which the macroseismic observations indicate a depth of the order of 100 km. The shock of April 13, 1938 (No. 253m) originated north of the Lipari Islands at a depth of 270 km., which makes it the deepest known earthquake outside of the circum-Pacific belt.

Apart from these, earthquakes in the European area are all taken to be

TABLE 15.—*Additional earthquake epicenters in North Africa*

Day	Time	Epicenter		Quality	Class
		Latitude, degrees	Longitude, degrees		
1930, Aug. 9	18:09:26	34 N.	5 W.	C	d
1926, Oct. 11	06:38:52	36 N.	3 W.	B	d
1927, Sept. 8	08:52:50	36 N.	$3\frac{1}{2}$ W.	B	d
1923, July 9	15:31:16	$35\frac{1}{2}$ N.	4 W.	C	d
1928, Aug. 24	09:44:15	36 N.	0	B	d
1924, March 16	10:17:25	35 N.	6 E.	B	d
1920, Feb. 25	17:56:23	35 N.	$9\frac{1}{2}$ E.	C	d
1924, Nov. 5	18:54:25	36 N.	4 E.	B	d
1929, Dec. 13	04:45:27	36 N.	14 E.	B	d
1935, April 19	15:23:26	32 N.	15 E.	A	b
1936, June 13	00:32:42	33 N.	$22\frac{1}{2}$ E.	B	d

shallow, although the depth of focus varies somewhat, being presumably deeper under the Alps and immediately north of them than elsewhere.

Historical records amply justify drawing an active line along the Apennines, though most of these shocks, in spite of their locally disastrous effects in towns where weak construction is prevalent, were not of large magnitude. As the line enters Calabria and turns into Sicily, stronger shocks, such as those of 1783, are encountered. Here the seismic line again parallels the southern boundary of Stille's *Neo-Europa*. It extends westward along the African coast, where the recent activity has been high enough so that additional epicenters could be taken from the International Summary and more recent bulletins (Table 15; Fig. 12). Notable activity occurs eastward along the coasts of Tunis and Libya. The shock on April 19, 1935, at 32° N. 15° E., was the largest in the western Mediterranean in recent years.

All this activity is close to the coasts, no epicenters being found in the western Mediterranean basin. The north coast is also active, particularly in southern Spain, though less so than the south coast. The seismic belt of the central Atlantic has a branch running eastward through the Azores, which links up naturally with the Mediterranean activity. This partly hypothetical seismic line should presumably include the great Lisbon earthquake of 1755.

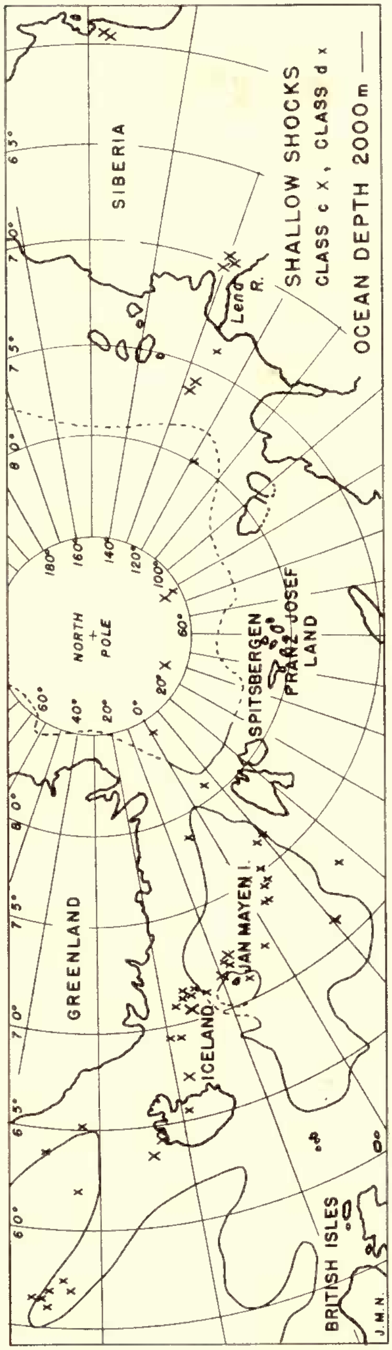

FIGURE 11.—*Map of epicenters, north polar region*

is on the commonly accepted boundary between the Angara stable shield and the structures of northeastern Siberia.

ATLANTIC BELT

The earliest systematic collection of data on Atlantic shocks is contained in the papers on seaquakes by Rudolph (1887; 1895). Shocks are felt on shipboard in the Atlantic chiefly near the Azores and in the central area near the equator. During the following 20 years it was found that comparatively few of these shocks were recorded by the instruments then in service in Europe and America. This showed that the activity reported by vessels must consist of comparatively small earthquakes, and it was suggested that much of it might be due to submarine volcanism. This is pretty certainly false; for with improved instruments epicenters began to be located in the Atlantic, and the energy of the shocks, though moderate, is still larger than that of any known volcanic disturbance. Sieberg and others had pointed out the association of seaquakes with the Mid-Atlantic Ridge; and Tams (1927a; 1928), using revised epicenters from the International Summary supplemented by other observations, showed that the Ridge is the chief locus of Atlantic seismicity.

The shocks in Figure 12 are largely different from those used by Tams, but the agreement with his results is very good. North Atlantic shocks are very favorably placed for epicentral determinations using the stations in Europe and North America; this is already less true of the equatorial active line, and is not true at all for the South Atlantic.

The Mid-Atlantic Ridge is not a mere rise or swell in the ocean bottom, but is shown by soundings to have a very complicated topography (Wüst, 1939a); it is in fact a submarine mountain range, as might be expected from the seismic activity following it. To the north it continues into the polar area.

The seismic belt has a branch passing eastward through the Azores, following their structural trend, (Wüst, 1939b) and presumably connecting with the Mediterranean active area. On the other side, there is no sign of seismicity between the Mid-Atlantic Ridge and the West Indies.

In the equatorial Atlantic the Ridge has a striking flexure, giving it a long nearly east-west course; this is faithfully followed by the seismic activity, which is higher here than elsewhere along the belt. This bend parallels the strong curves in the coasts of Africa and South America.

To the south the extensions of both the Ridge and the seismic belt are less definite. Tams (1931) suggests drawing the lines round the south of Africa into the Indian Ocean, which would connect with the active belt of that region. This possibility cannot be rejected, but others are equally likely. The small number of located epicenters in the South Atlantic is partly due to a real falling off in seismicity, as well as to the increased difficulty of location.

TABLE 17—*Concluded*

Day	Time	Epicenter		Quality	Class
		Latitude, degrees	Longitude, degrees		
1923, Sept. 26	02:29:20	1½ N.	29½ W.	C	c
1923, Aug. 8	12:17:25	½ N.	30 W.	C	c
1920, Nov. 12	05:41:38	1 N.	28 W.	B	c
1924, June 20	16:21:34	0	26 W.	C	d
1920, Dec. 5	10:01:15	0	17 W.	B	d
1929, Jan. 18	21:27:45	1 N.	17 W.	B	d
1928, May 12	20:28:00	1 N.	19 W.	B+	c
1928, Sept. 18	17:19:20	0	20 W.	B	c
1929, March 31	03:09:53	1 S.	15 W.	C	c
1925, Aug. 20	23:04:30	1 S.	21½ W.	C	c
1925, Sept. 12	14:14:58	1 S.	19 W.	C	d
1929, June 5	10:50:11	1 S.	14½ W.	A	c
1924, Oct. 12	19:34:10	½ S.	29 W.	B	c
1923, July 20	15:02:37	1½ S.	13½ W.	B	c
1929, Feb. 2	00:00:19	1½ S.	21 W.	A	b
1920, July 4	00:11:40	2 S.	14 W.	C	d
1928, Aug. 3	11:44:42	2 S.	14 W.	B	c
1929, Aug. 22	19:40:53	3 S.	21 W.	C	c
1922, Nov. 8	23:33:45	6½ S.	11 W.	C	d
1928, April 3	16:42:45	11½ S.	14½ W.	B	c
1926, May 17	21:42:17	14½ S.	14 W.	C	c
1929, July 25	22:57:17	13½ S.	14 W.	B	c
1925, Dec. 15	10:31:31	25 S.	9 W.	C	c
1925, June 13	20:23:10	29 S.	22 W.	B	c
1930, Dec. 25	13:07:19	33 S.	13 W.	C	c
1928, Nov. 22	08:31:01	56½ S.	3 W.	B	c
1920, Sept. 4	14:09:02	55 S.	2 E.	C	c
1927, Nov. 14	15:04:35	54 S.	8 E.	B	c
1928, July 19	23:38:45	55½ S.	9 E.	B	c
1935, Feb. 6	01:53:56	31 N.	42 W.	B	c
1938, Feb. 15	03:27:42	19 N.	26 W.	A	c
1939, May 8	01:46:50	37 N.	24½ W.	A	b
1939, June 5	23:03:31	36 N.	34½ W.	C	d
1939, June 22	19:19:31	6 N.	1 W.	A	c
1937, Aug. 22	11:31:44	7 N.	36 W.	B	c
1937, Oct. 6	21:48:02	1 N.	29 W.	C	c
1937, Dec. 28	06:19:26	1 N.	29 W.	B	c
1937, Dec. 13	22:58:47	26 N.	45 W.	C	d
1938, March 1	23:26:58	55 S.	12 E.	B	c
1939, Aug. 2	00:46:22	36 S.	16 W.	B	c

INDIAN OCEAN BELT

A seismic belt, in many respects similar to the Arctic-Atlantic belt, passes through the western Indian Ocean. Maps by Tams (1931) and other investigators carry no suggestion of such a line; they indicate only a few isolated epicenters in the whole area. The belt first appears plainly

TABLE 18.—*Additional earthquake epicenters in the Indian Ocean*

Day	Time	Epicenter		Quality	Class
		Latitude, degrees	Longitude, degrees		
1929, April 28	04:58:44	14½ N.	53 E.	B	d
1928, March 19	10:02:06	14½ N.	53½ E.	B	d
1924, April 20	14:27:04	15 N.	52 E.	B	c
1929, March 16	12:30:52	14 N.	52 E.	C	d
1928, Sept. 18	19:52:37	14 N.	52 E.	A	c
1923, Dec. 10	23:53:38	13½ N.	50 E.	C	d
1926, Jan. 5	10:03:24	11 N.	58 E.	B	d
1928, July 4	17:53:38	10 N.	57 E.	B	c
1929, Jan. 1	13:58:18	9½ N.	62 E.	C	d
1925, Feb. 2	18:44:31	9 N.	62 E.	C	d
1928, July 6	00:48:05	4 N.	62½ E.	C	c
1927, Aug. 18	01:50:55	5 N.	63 E.	C	d
1930, Aug. 23	15:07:40	6 N.	65 E.	C	d
1926, Dec. 2	16:41:47	1 N.	67 E.	C	d
1923, May 28	01:25:53	1½ S.	88½ E.	B	c
1926, Jan. 18	21:07:23	2 S.	89 E.	B	c
1928, Feb. 7	00:01:43	2½ S.	88½ E.	A	c
1928, March 9	18:05:27	2½ S.	88½ E.	A	b
1930, March 9	08:52:26	3 S.	71 E.	C	d
1922, Sept. 8	14:14:13	2½ S.	68 E.	C	d
1922, July 3	05:29:22	8½ S.	66 E.	B	c
1929, Feb. 17	20:44:17	8½ S.	67 E.	C	d
1929, May 5	16:56:43	13 S.	66 E.	B	d
1922, Feb. 14	12:45:22	13½ S.	67 E.	C	d
1925, July 8	04:56:02	14½ S.	67 E.	C	d
1928, Oct. 25	12:36:19	13½ S.	68½ E.	C	d
1926, Dec. 24	07:01:10	19 S.	65 E.	C	d
1923, Nov. 26	12:18:37	31 S.	58 E.	C	d
1930, April 27	14:26:22	33 S.	59 E.	B	d
1925, April 11	10:42:02	34 S.	59 E.	B	b
1925, May 3	22:59:04	34 S.	58 E.	B	b
1925, May 19	05:23:45	33½ S.	58 E.	B	b
1925, May 28	05:55:11	35 S.	56 E.	C	c
1925, July 7	08:14:02	35½ S.	59½ E.	C	c
1925, Oct. 12	05:44:40	34 S.	60 E.	B	c
1926, March 21	12:05:58	34 S.	58½ E.	C	c
1926, May 31	13:35:49	33½ S.	57 E.	B	c
1926, Sept. 2	01:21:52	33½ S.	59 E.	B	b
1926, Dec. 2	08:13:44	34 S.	57 E.	C	c
1927, March 21	15:05:34	33 S.	58 E.	B	c
1927, April 11	22:03:50	34 S.	59 E.	C	c
1927, April 16	09:11:10	33½ S.	58½ E.	C	c
1927, Sept. 10	16:28:15	34 S.	57 E.	C	c
1927, Oct. 19	13:48:40	34 S.	59 E.	C	c
1927, Nov. 8	03:10:28	34 S.	60 E.	A	c
1928, Jan. 30	03:15:24	33 S.	59 E.	B	c

temperature distribution suggests a division of the Indian Ocean below 4000 meters into two regions separated by a continuous barrier extending from the Mascarene Islands to the Kerguelen Ridge north of Amsterdam Island.

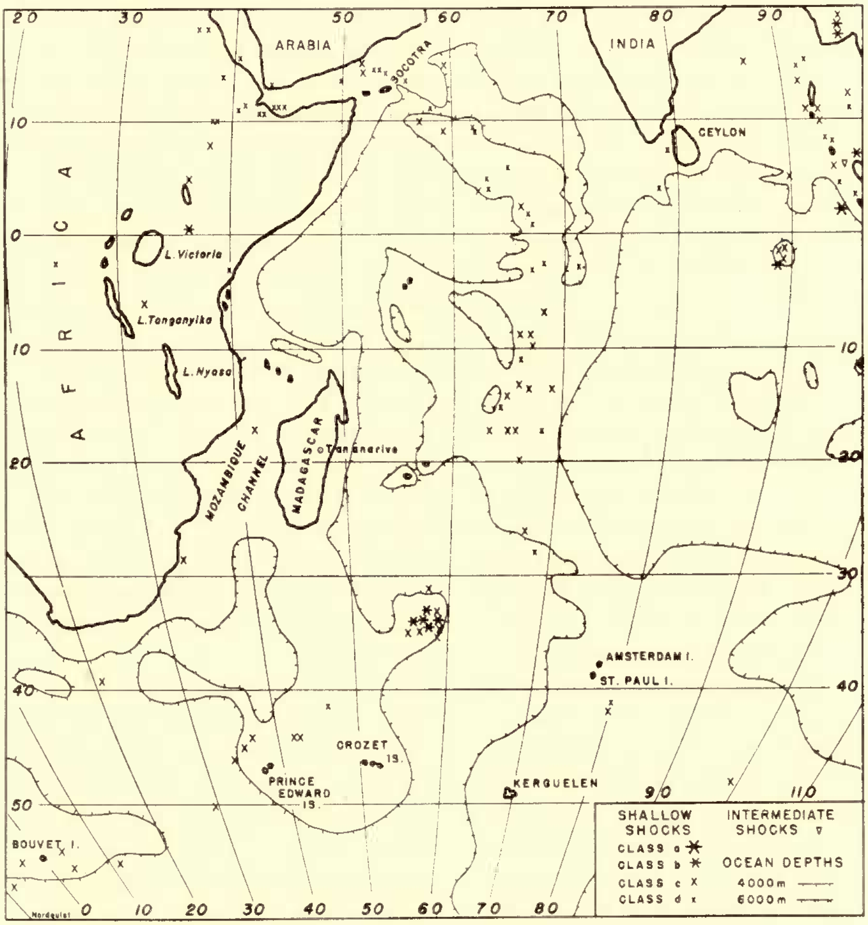

FIGURE 13.—*Map of epicenters, Indian Ocean and east Africa*

The main seismic belt begins abruptly off the coast of Arabia north of the island group of Socotra. The trend is roughly southeastward along the ridge discovered by Schmidt and called the Carlsberg Ridge, which has been confirmed recently by the work of the John Murray Expedition (Farquharson, 1936; review by Hoffmeister, 1938). Near the equator the belt changes direction rather sharply (this is as apparent on a globe as on Fig. 13), and continues west of south. About 30° S. 65° E. the prevailing compared with the Atlantic and Indian Ocean belts, which in turn are much less active than the Pacific and Asiatic belts. It has been difficult to extract from the available seismometric data the small group of fairly well-determined epicenters included in Table 19 (Fig. 13). The years just

TABLE 19.—*Additional earthquake epicenters in East Africa*

Day	Time	Epicenter		Quality	Class
		Latitude, degrees	Longitude, degrees		
1921, Aug. 14	13:15:28	15½ N.	40½ E.	C	d
1921, Sept. 21	11:01:31	14 N.	39 E.	C	d
1926, Oct. 30	01:38:10	11 N.	44 E.	C	d
1929, Jan. 22	14:43:05	11½ N.	43½ E.	B	d
1930, Oct. 27	23:28:41	12½ N.	43½ E.	C	d
1929, May 18	01:02:12	11½ N.	41½ E.	B	d
1930, Oct. 25	17:41:55	11½ N.	44 E.	C	d
1930, Oct. 24	10:47:21	10½ N.	43 E.	C	d
1928, Oct. 4	18:22:58	7 N.	38 E.	B	c
1928, Jan. 6	19:31:58	½ N.	36½ E.	A	b
1929, July 26	17:18:50	2½ S.	24½ E.	C	d
1919, July 8	21:06:25	6 S.	32½ E.	B	c
1938, July 21	09:10:42	3 S.	40 E.	B	d
1938, May 12	21:31:32	18 N.	37½ E.	B	d
1938, Sept. 27	02:31:49	11 N.	41 E.	C	d
1939, Jan. 23	02:22:53	32 N.	16 E.	A	d
1938, Oct. 20	13:14:58	10 N.	38½ E.	C	d
1938, Oct. 23	02:25:14	10 N.	38½ E.	C	d
1937, Nov. 30	12:57:46	5 N.	36 E.	B	c

preceding the higher development of precise seismometry were a period of greater activity in East Africa than any time since. The shock of December 13, 1910, has been dropped from the list of great earthquakes (magnitude 7½ ?); it was felt over a very wide area, and was strong in the vicinity of Lake Tanganyika. (*See* Sieberg, 1932a, p. 883.)

The complexity of the known rift structures is reflected in the seismicity, which is not confined to any single narrow line in the equatorial region. A seismic belt runs northeast through Ethiopia to the head of the Gulf of Aden. There is also activity along the west coast of the Red Sea; but the seismological evidence does not indicate any continuous active line drawn from central Africa across Suez into the unquestionably active Jordan trough of Palestine. (Note the destructive Palestine earthquake of July 11, 1927 on Figure 10.) Any such projection of the African rifts must be based on geological and geomorphological evidence. The occasionally encountered assertion, that there is a seismically active belt following such a course, is based on papers published in an earlier epoch of seismology.

quakes, located erroneously on the supposition of normal focal depth. Others are simply inadequately recorded, or too much weight has been placed on the data of one or two stations with inferior instruments.

The following discussion includes only the 18 shocks, which the International Summary places well out in the Pacific basin. Hawaiian shocks are omitted. Shocks are given in order of latitude from north to south. Accurate location is out of the question unless several stations in different directions from the epicenter have recorded P, the first seismic motion; it is usually difficult and doubtful without several consistent readings for S. Other readings, referring usually to reflected waves and surface waves, are of little use in finding the epicenter; these will be noted as "late readings."

43° N. 170° E. Oct. 6, 1921, 15^h. P and S at Mizusawa and Eskdalemuir give origin time 2 minutes later than in the Summary and a very different epicenter. S at other European stations may be a late phase. Possibly deep focus; perhaps an intermediate shock in the Kurile Islands.

40.5° N. 160.5° E. Aug. 27, 1927, 12^h. Usefully recorded at seven stations. The given solution roughly fits Zi-ka-wei, Irkutsk, Baku, and Tiflis but not Ekaterinburg and Tashkent. Ootomari reports a time which is much too early to fit, and Mizusawa appears to begin 2 minutes late. It is impossible to tell which data are correct.

40.5° N. 160.5° E. April 21, 1930, 21^h. Nine stations, three with no P. The solution fits only Zi-ka-wei and Baku, and is marked *X*, which means that "there is much uncertainty as to even the approximate origin."

34° N. 162° W. June 17, 1917, 08^h. Five stations; only one P, no S. Melbourne flagrantly inconsistent. No evidence for the indicated epicenter.

30° N. 174° W. Oct. 1, 1918, 00^h. "Very unsatisfactory." A badly forced solution. P and S only at Tokyo, except that a surface wave reported at Honolulu for the next hour (when there was also a shock) is assumed to be P with an error of 1 hour, though it still comes out 58 seconds early.

26.8° N. 172.0° E. Oct. 11, 1928, 23^h. Two shocks, 12 minutes apart. Epicenter by the Russian stations, does not fit well. More probably Aleutian Islands near 52° N. 175° E.

16.0° N. 153.5° E. May 14, 1923, 02^h. Four stations, only two with P. "Very rough." Data insufficient.

12.5° N. 168.0° E. Sept. 19, 1923, 08^h. P only at Osaka. The solution fits only a small part of the data. Possibly in the Tonga salient.

11.7° N. 176.0° E. May 21, 1918, 11^h. P and S at Riverview; S at Manila. Other stations have only late readings. May be anywhere in the Pacific area.

9° N. 155° E. May 16, 1925, 10^h. Eastern Caroline Islands. Depends on Manila, Riverview, Batavia, and Ekaterinburg and cannot be rejected definitely; to bring it into the active belts would require an error of 10 or more degrees.

9° N. 155° E. Sept. 29, 1926, 05^h. Two shocks. "Very rough indeed." Almost all data are late readings and many do not fit.

9° N. 155° E. March 3, 1928, 17^h. Tashkent and Ekaterinburg have P and S in rough agreement with the given solution. Manila and Zi-ka-wei do not fit. Other stations have only late readings. Data insufficient.

5° N. 148° E. Jan. 21, 1920, 06^h. Fitted to P and S at Riverview. Readings at other stations are imperfect, and none of them fit, except a possible S at Batavia.

In the middle of September 1929 a swarm of small shocks began in the northwestern part of the Island of Hawaii near the dormant volcano Hualalai, which erupted last in 1802. Larger shocks occurred; that of September 26, at 04^h, was recorded as far as western Europe. The largest shock of the group (magnitude $6\frac{3}{4}$) took place on October 6, at 07^h. There were effects of much violence, and extensive damage, in the Kona district, which includes Hualalai. The seismograms are of the usual character for shallow earthquakes. The International Summary gives for these two larger shocks an epicenter, on the east coast of Hawaii, but the data agree very well with the macroseismic epicenter at Hualalai near 19.8° N. 155.9° W. No eruption was associated with this group of shocks.

Two shocks of about the same magnitude occurred on January 23, 1938, at about 21° N. 156° W., and on June 17, 1940, 10:26:47 at $20\frac{1}{2}$° N. $155\frac{1}{4}$° W. Honolulu, as in 1871 and 1881, occasionally has been heavily shaken by earthquakes which were not so strong elsewhere in the islands.

CANADIAN SHIELD

The writers' use of terms like the Canadian Shield is geographical, and is not meant to express preference for any particular interpretation in terms of historical geology. The term "Laurentian Shield" might be preferable; the reference is to that large part of Canada, with a small area in the United States, over most of which the pre-Cambrian rocks of the Laurentian series are exposed at the surface.

The interior of the Canadian shield, thus defined, appears to be completely aseismic. Because of the proximity of good stations it is sure that only minor shocks could have escaped notice. However, the marginal part of the shield is subject to occasional large shocks, with fairly frequent minor local disturbances. Of the four known larger shocks, three originated near the St. Lawrence River. These are the great earthquake of 1663, which was violent near Three Rivers (roughly $46\frac{1}{2}$° N. $72\frac{1}{2}$° W.), the large shock of March 1, 1925 (Feb. 28, 1925, local time) in the Saguenay River district at about 48.2° N. 70.8° W., and the moderate shock of October 19, 1939, at about 47.8° N. 69.9° W. The 1925 shock is No. S1 of the deep-focus list; however, the depth of 50 km. assigned to it is probably usual for this region and might be called "shallow." To these add the Timiskaming earthquake of November 1, 1935, near 46.1° N. 79.1° W.; this is No. S2, with depth estimated roughly as 80 km. It is doubtful whether the New Hampshire earthquakes of December 20 and 24, 1940 (44° N. 71° W.) should be included here or with the Appalachian shocks.

A second group of such marginal shocks is that of the Baffin Bay earthquake of September 20, 1933 (Table 4) and its aftershocks. It is a good instance of the occasional unexpected occurrence of a large shock in a region not previously considered to be active. Small shocks have often been reported felt on the west coast of Greenland (Tams, 1922) and Ter-

Still more definitely, there is not a single good instrumental epicenter; although a chain of first-class stations at Moscow, Baku, Sverdlovsk (formerly Ekaterinburg), Tashkent, Irkutsk, and Vladivostok was established under the imperial Russian government, and has been maintained by the Soviet government with the addition of important local networks in Crimea, the Caucasus, and central Asia. The few epicenters in this area given by the International Summary are as bad as those in the Pacific, or worse.

On the south and southeast the stable mass is bounded by the active belt of the central Asiatic highlands. In the northeast is the active area near the mouth of the Lena, which is at the end of the known extent of the Arctic active belt. Between these, the border of the Angara shield has shown no verifiable recent activity.

On seismological evidence alone the stable mass might be made to include the extreme northeastern part of Asia, east of the Lena and the Angara shield, excluding Kamchatka. Here the only known shocks are near the coast. Since this area appears to differ geologically from the stable masses, it is discussed in the next main section.

AFRICA

The huge African stable mass appears on Figures 12 and 13. Most of the epicenters shown are the result of systematic search, which has been carried out as carefully as for the Pacific basin.

The African rift zones have already been considered, and the shocks of the Mediterranean coast have been discussed with the trans-Asiatic zone. Between the equator and 30° N., outside of the Rift and Red Sea regions the International Summary lists only four small shocks, for which the data are either very scanty or very inconsistent.

The Summary locates two shocks at 3° S. 24° E. For one of these, in 1922, the data are insufficient even to establish the region of occurrence; this might be a misplaced Rift shock. The other, that of July 26, 1929, has been accepted with a slight shift in epicenter (Table 19). The location is not good, and the epicenter has been retained largely in order to have definite representation of the shocks which undoubtedly occur in this region west of the Rifts. For reports of shocks felt here *see* Sieberg (1932a, p. 879–881). These are our only seismological evidence of the separation between the units composing the African mass.

The long history of Egypt includes a few strong shocks which appear to have originated on the continent. Some of these are listed by Sieberg (1932a, p. 873; 1932b). The clearest cases of strong shocks are those of 1303 and 1847, apparently centering in the Fayum west of Cairo. The great shock of 1870 was probably an intermediate earthquake under the Mediterranean.

A few epicenters are mapped about the margins of Africa. In some cases northward into the interior from the neighborhood of Adelaide. Only the following shock could be located:

1939, March 26	3:56:08	31° S.	138° E.	B	d

The International Summary contains no well-located continental Australian epicenters. Off the northwest coast is an epicenter (unmapped) at 16½° S. 121° E., August 16, 1929 (Table 18).

ANTARCTICA

The records obtained by the DISCOVERY expedition in 1902 have been discussed already. Teleseismic observation indicates that the whole of Antarctica is completely inactive. This fact has sometimes been obscured by vague references to shocks in "the Antarctic" which were actually in the Southern Antilles or the Macquarie Island loop. In both regions verifiable activity extends somewhat south of the 60th parallel.

The International Summary and its predecessor reports assign only 11 shocks from 1913 to 1930 and none since then to latitudes from 65° southward. These data have been reviewed with close attention. It was hoped that some of the results could be accepted, as in this part of the globe a single epicenter, established from instrumental data, would be of great significance, even though the location could not be specified within 10 degrees. However, none of these epicenters are satisfactory. The following notices are shorter than for the supposed shocks of the Pacific basin. The same general remarks as to importance of P and S, late readings, and so forth, apply. Nearly all these epicenters depend principally on reported times at La Paz for P and S. Other data are mostly doubtful and late readings. Most of these shocks might be in any of the active regions of southern latitudes.

65° S. 0° E. July 15, 1917, 10^h. Does not fit the data, not even the S at La Paz.

65° S. 0° E. June 16, 1921, 09^h. La Paz and a few late readings.

65° S. 39° W. May 20, 1920, 04^h. La Paz, doubtful S at Helwan, and late readings.

65.7° S. 50° W. Dec. 6, 1929, 11^h. Only four P's, all in South America. A revised solution gives 65° S. 47° W.; the epicenter depends delicately on the time of S at Tananarive. This is a southern member of the Southern Antillean group, but the location is inaccurate.

66.5° S. 170° E. Aug. 14, 1929, 02^h. "Very doubtful." P at five stations only. Comparison indicates an epicenter within a few degrees of that of Oct. 9, 1938, at 61° S., 160° E. (Table 9).

68° S. 90° W. Dec. 5, 1927, 17^h. P and S at La Paz and Sucre, S at La Plata, and late readings.

69° S. 10° E. Jan. 13, 1923, 09^h. La Paz, doubtful S at Riverview (reported as P), and late readings.

69° S. 108° W. Sept. 1, 1919, 19^h. La Paz, possibly S at Riverview and Melbourne, and late readings.

73° S. 120° W. March 22, 1917, 02^h. La Paz, and late readings in Europe.