AGE AND DISTRIBUTION OF PEGMATITES

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AGE[1]

INTRODUCTION

Pegmatites have been formed during periods of intrusive igneous activity from the pre-Cambrian to the present. A *detailed* age classification of such deposits is impossible of compilation at present. Most pegmatites occur in regions of crystalline rock where age determinations from field observations are usually approximations at best. However, important progress has been made during the last decade in determining the age of pegmatites and other mineral bodies containing radioactive minerals by determining the ratios between lead and uranium and thorium.[2] Analyses have shown that the pegmatites in the great pre-Cambrian shield areas, many of which are undatable from geological evidence, are themselves pre-Cambrian in age. Most of the analytical work to date in rocks younger than the pre-Cambrian has been for the purpose of building up a time scale through obtaining specimens from rock bodies which were already fairly well placed in the geologic column by field observations. In the future more use can be made of this method to determine the age of pegmatites and other radioactive mineral-bearing deposits which are impossible of dating by field observation. This has already been done by Foye[3] in New England.

THE PRE-CAMBRIAN PEGMATITES

Pegmatites are abundant in the pre-Cambrian areas of the Laurentian Shield of northeastern North America, the Fenno-scandian Shield in northwestern Europe (including Scotland), and in the Gondwanaland belt of South America, Africa, India, and Australia. In addition many smaller areas of pre-Cambrian rock

[1] The writer gratefully acknowledges helpful criticism given during the preparation of this chapter by A. C. Lane and J. P. Marble.

[2] Holmes, Arthur, Radioactivity and geological time: *Nat. Research Council, The Age of the Earth,* pp. 124–459, **1931**. Lane, Alfred C., *Nat. Research Council, Rept. of the Committee on the Measurement of Geological Time,* **1933**.

[3] Foye, W. G., and Lane, A. C., Correlations by radioactive minerals in the metamorphic rocks of southern New England: *Am. Jour. Sci.* (5) vol. **28,** pp. 127–138, 1934.

contain pegmatites. Examples of the latter in North America are the belt of pre-Cambrian rocks in the Appalachian Mountain region, a large number of districts in the Rocky Mountain area, and the inner gorge of the Grand Canyon of Arizona.

Simple pegmatites (those in which no hydrothermal replacement has taken place[4]) are extremely common in the pre-Cambrian terrane. Many of these are of the lit-par-lit type. Some of the simple pegmatites are sufficiently large to be exploitable for feldspar or mica or other minerals. Complex pegmatites were also formed during pre-Cambrian time. Examples are the lithium pegmatites of Western Australia and the Rocky Mountain belt (including the Black Hills) of North America; the rare earth pegmatites[5] of Llano County (Texas), Minas Geraes (Brazil), Ytterby (Sweden), Tanganyika, and India; and the beryl pegmatites of Brazil and South Africa.

Paleozoic Pegmatites

Pegmatites of Paleozoic age are found wherever the Paleozoic era was marked by intrusive igneous activity. One of the best regions illustrating this is New England and the Paleozoic Appalachians to the southwest. According to Bastin,[6] the granites of Maine were intruded in Late Silurian or Devonian time, and the pegmatites are also probably of that age. The Strickland pegmatite at Portland, Connecticut, the near-by Hale deposit (Glastonbury), and the Blueberry Mountain pegmatite at Woburn, Massachusetts, are Devonian in age.[7] The famous Bedford pegmatite in Westchester County, New York, intrudes the Ordovician Hudson schist.[8] The ages of both this and the Branchville, Connecticut, phosphate pegmatite have been determined by the lead-uranium ratio to be 380 million years, which corresponds to the Late Ordovician (Taconic revolution).[9] Virginia and the Carolinas

[4] Landes, Kenneth K., Origin and classification of pegmatites: *Am. Mineral.* vol. **18,** pp. 33–56, and 95–103, 1933.

[5] Holmes, Arthur, Radioactivity and geological time: *Nat. Research Council, The Age of the Earth,* pp. 276 et. seq., **1931**.

[6] Bastin, Edson S., Geology of the pegmatites and associated rocks of Maine: *U. S. Geol. Survey, Bull.* **445,** p. 15, 1911.

[7] Lane, Alfred C., *Rept. of the Committee on the Measurement of Geological Time: Nat. Research Council,* pp. 11–13, **1933**.

[8] Bastin, Edson S., Feldspar and quartz deposits of southeastern New York: *U. S. Geol. Survey, Bull.* **315,** pp. 394–395, 1906.

contain pegmatites both in the pre-Cambrian and in the Late Paleozoic.[10] Many of the pegmatites in the New England-Appalachian belt are complex, exhibiting lithium, boron, phosphate and other phases. Paleozoic alkaline syenite pegmatites occur on Mount Royal, Montreal.

Intrusions of pegmatite accompanied Paleozoic ore deposition in widely scattered parts of the globe. Tungsten-bearing pegmatites in England are post-Silurian in age.[11] Both tin and tungsten minerals occur in pegmatitic quartz veins accompanying the Paleozoic granites of western Spain.[12] Tin-bearing pegmatite dikes in eastern Victoria cut the Silurian metamorphic series.[13] Pegmatites associated with the ore deposits of the New England area of New South Wales are related to Carboniferous and Permo-Carboniferous granite. Ore-bearing pegmatites accompany Devonian granite in northern Tasmania.[14] A Paleozoic age is assigned by Holmes[15] to the rare earth pegmatites of Langesundfjord, Southern Norway, and Miask, Urals.

Mesozoic Pegmatites

The great batholiths which were intruded in the latter part of the Mesozoic in the Cordilleran region of western North America were accompanied by pegmatites. Granitic pegmatites occurring in British Columbia are referred to the Lower Cretaceous.[16] Peg-

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[9] Agar, Wm. M., The pegmatites of Bedford, New York: *Sixteenth International Geological Congress, Guidebook* **9,** p. 126, 1933.

[10] Pegau, A. A., The pegmatites of the Amelia, Goochland, and Ridgeway areas, Virginia: *Am. Jour. Sci.* (5), vol. **17,** pp. 543–547, 1929. Lonsdale, John T., Geology of the gold-pyrite belt of the northeast piedmont, Virginia: *Virginia Geol. Survey, Bull.* **30,** pp. 1–110, 1927. Keith, Arthur, The Gaffney-Kings Mountain Folio, South and North Carolina: *U. S. Geol. Survey, Geol. Folio* **222,** 1931.

[11] Finlayson, A. M., Ore-bearing pegmatites of Carrock Fells: *Geol. Mag., n.s.,* vol. **7,** pp. 19–28, 1910.

[12] Krusch, P., Die Beziehungen der Wolframite- und Bleierzlagerstätten Westspaniens zu Graniten und zur Tektonik: *Deut. Geol. Ges. z. Monatsb.,* vol. **80** (1–2), pp. 34–46, April 10, 1928. Abstract in *Annotated Bibliography of Econ. Geology,* no. **210,** 1928.

[13] Dunn, E. J., Tin ore at Glen Wills: *Records Geol. Survey Victoria,* vol. **2,** pt. 2, pp. 104–105, 1907.

[14] Reid, A. McIntosh, The mining fields of Morina, Mt. Claude, and Lorinna: *Tasmania Geol. Survey, Bull.* **29,** pp. 34–36, 1919.

[15] *Op. cit.,* pp. 300–311.

[16] Dolmage, Victor, Finlay River district, British Columbia: *Canadian Min.*

matites, some of them complex, accompanied the intrusion of the Idaho batholith.[17] The age of this batholith is variously estimated as end of Jurassic, late Cretaceous, and early Eocene.[18] The country rock into which these pegmatites are intruded is pre-Cambrian at several localities. Pegmatites likewise accompany the Mesozoic batholiths of Oregon,[19] Montana,[20] Nevada,[21] and California.[22] A number of the minerals found at Crestmore, California, were formed through the action of pre-Cretaceous pegmatite dikes on Paleozoic (?) limestone.[23] The pegmatites of San Diego, California, world famous for their tourmaline crystals and lithium minerals, are of Mesozoic age, probably Jurassic.[24]

Albite and diabase pegmatites of Triassic age occur in Virginia[25] and pyrite-bearing pegmatites occur in the Triassic diabase of the Palisades.[26] Pegmatite dikes which are probably related to post-Permian granitic intrusions occur in the Vosges region of France.[27] A pegmatitic ore deposit in Austria, of pre-middle Cretaceous age, has been described by Friedrich.[28] The rare earth

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Jour., vol. **50,** no. 8, pp. 164–168; no. 10, pp. 214–217, 229, 1929. Abstract in *Annotated Bibliography of Econ. Geology*, vol. **2,** pt. 2, p. 92.

[17] Shannon, E. V., Note on garnet from a pegmatite in Idaho: *Am. Mineral.*, vol. **7,** p. 172, 1922. Thomson, F. A., and Ballard, S. M., Geology and gold resources of north-central Idaho: *Idaho Bur. Geology and Mines*, vol. **7,** p. 34, 1924.

[18] Anderson, A. L., Genesis of mica pegmatite deposits, Latah County, Idaho: *Econ. Geology*, vol. **28,** no. 1, pp. 41–58, 1933.

[19] Goodspeed, G. E., Certain pegmatitic facies of the Wallowa Mountains batholith in northeastern Oregon: *Bull. Geol. Soc. Am.*, vol. **44,** pt. 1, p. 160, 1933.

[20] Barrell, Joseph, Geology of Marysville mining district, Montana: *U.S. Geol. Survey, Prof. Paper* **57,** pp. 16–17, 1907.

[21] Knopf, A., Geology and ore deposits of the Rochester district, Nevada: *U.S. Geol. Survey, Bull.* **762,** p. 52, 1924. Ball, Sydney H., The post-Jurassic igneous rocks of southwestern Nevada: *Jour. Geology*, vol. **16,** pp. 43–44, 1908.

[22] Turner, H. W., The granitic rocks of the Sierra Nevada: *Jour. Geology*, vol. **7,** pp. 141–162, 1899.

[23] Daly, John W., Paragenesis of mineral assemblage at Crestmore: (Abstract) *Pan-American Geologist*, pp. 312–313, May, **1933.**

[24] Engel, René, Personal communication, dated April 18, 1934.

[25] Shannon, E. V., *Proc. U.S. Nat. Mus.*, vol. **66,** art. 2, 1924. Abstract in *Mineralog. Abstracts*, vol. **3,** p. 204.

[26] Kemp, J. F., The role of the igneous rocks in the formation of veins: *Trans. Am. Inst. Min. Engrs.*, vol. **31,** p. 182, 1901.

[27] Karpinski, R. W., Contribution a l'étude métallogénique des Vosges méridionales, pp. 1–142, Nancy, 1931. Abstract in *Annotated Bibliography of Econ. Geology*, vol. **4,** pt. 2, no. 216.

[28] Friedrich, O., Eine alte, pegmatitische Erzlagerstätte der Ostalpen: *Neues*

pegmatites occurring in the granite of Ishikawa in the Province of Iwaki in Japan are referred to the Mesozoic, probably Jurassic.[29]

Cenozoic Pegmatites

The area of outcrop of Cenozoic intrusive rocks is relatively small so pegmatites are not abundant. Undoubtedly the number will increase in the geologic future as erosion removes more of the rock overlying the Cenozoic intrusives. A basic pegmatite of probable Tertiary age occurs in the Cooke City district of Montana.[30] In the Carlingford district of Ireland, the Carboniferous limestone has been metamorphosed by a series of Tertiary intrusives, ranging from basic to acidic. Pegmatitic satellites of the acidic Tertiary magma reacted with the skarns formed through the earlier metamorphism to produce an unusual suit of minerals.[31] Another example of Cenozoic pegmatites, in northern Italy immediately south of the southeastern corner of Switzerland, has been described by Cornelius.[32] Tertiary pegmatites containing beryl, dumortierite, and uraninite occur in this area.

Summary and Conclusions

The greater number of the known pegmatites of the world are pre-Cambrian in age, although Paleozoic and Mesozoic pegmatites are common in areas which have been scenes of intrusive igneous activity during those eras, and Cenozoic pegmatites, although uncommon, are not unknown. There are several reasons for the predominance of pre-Cambrian pegmatites. In the first place the outcrop area of the pre-Cambrian is much greater than that of the younger crystalline rocks. For example, approximately 30 per cent of North America is covered by pre-Cambrian at the surface (or immediately beneath the mantle rock) and of the remaining 70 per cent only a very small proportion is represented

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Jahrb., Beil.-Bd. **65,** Abt. A (3), pp. 479–503, 1932. Abstract in *Annotated Bibliography of Econ. Geology*, vol. **5,** pt. 2, no. 251.

[29] Holmes, Arthur, *Op. cit.*, p. 315.

[30] Lovering, T. S., Magmatic chalcopyrite, Park County, Montana: *Econ. Geology*, vol. **19,** pp. 636–640, 1924.

[31] Osborne, G. D., The metamorphic limestones and associated contaminated igneous rocks of the Carlingford district, Co. Louth: *Geol. Mag.*, vol. **69,** no. 815, pp. 209–233, 1932.

[32] Cornelius, H. P., Über Auftreten und Mineralführing der Pegmatite in Veltlin und seinen Nachbartälern: *Centr. Mineral.* Abt. A., pp. 281–287, **1928.** Abstract in *Annotated Bibliography of Econ. Geology*, vol. **2,** pt. 2, no. 224.

by crystalline rock outcrops. Furthermore, the time represented by the exposed pre-Cambrian is over two-thirds of the known span of geologic time. During this long period a number of revolutions which were accompanied by large-scale igneous intrusion and pegmatite mineralization took place. A possible explanation, beside the selective solution theory of Lane[33] or the differential anatexis theory of Eskola[34] and others, of the much greater abundance of lit-par-lit pegmatites in the pre-Cambrian lies in the schistose condition of much of the country rock into which the pre-Cambrian batholiths were intruded. This type of surrounding rock encouraged the movement of magmatic liquids along planes of easier penetration. Similar pegmatization of the country rock took place in New England and portions of the Appalachian area during Paleozoic time where the pre-intrusive rock was very similar to much of that in the pre-Cambrian. As a general rule, younger intrusives have encountered rock of much more homogeneous character (in respect to permeability) so that the magmatic solutions, instead of forming lit-par-lit pegmatites, deposited feldspar, quartz, and other minerals in a contact metamorphic aureole in the adjacent rock.

Pegmatites are most abundant where erosion has stripped off the greater part of the cover above the source batholith. But erosion down to the "mountain roots" is not essential. Both Anderson[35] and Thomson and Ballard[36] have pointed out the upward increase in abundance of pegmatites in the upper part and overlying shell of the Idaho batholith. Similar observations have been made in parts of the Canadian Shield area where pegmatites are very abundant in the country rock adjacent to batholithic cupolas.

DISTRIBUTION

Introduction

The following pages contain a compilation of pegmatite occurrences throughout the world. Principal localities are listed for

[33] Lane, A. C., Origin of granites as well as metamorphic crystals by selective solution: *Bull. Geol Soc Am.*, vol. **24,** p. 704, 1913. Size of batholiths: *Op. cit.*, vol. **42,** pp. 813–824, 1931.

[34] Eskola, Pennti, On the differential anatexis of rocks: *Comptes Rendus Soc. Geol. de Finlande*, vol. **7,** pp. 12–25, 1933.

[35] Anderson, Alfred L., Geology and mineral resources of eastern Cassia County, Idaho: *Bull. Idaho Bur. Mines and Geology*, vol. **14,** pp. 1–164, 1931.

[36] Thomson, F. A., and Ballard, S. M., Geology and gold resources of north-central Idaho: *Bull. Idaho Bur. Mines and Geology*, vol. **7,** p. 34, 1924.

each geographic division, and brief mention is made of the more important pegmatite types. The nomenclature used is that which was employed by the writer in a recently published classification of pegmatites.[37] The discussion under each geographic division is followed by a selected list of references. In addition the following publications were freely drawn upon:

Aitkins, Irene, Emeralds: *U. S. Bur. Mines, Infor. Circ.* **6459,** pp 1–18, 1931; Tourmaline, *U.S. Bur. Mines, Infor. Circ.* **6531,** Nov., 1931. Holmes, Arthur, Radioactivity and geological time: *Age of the earth; Physics of the earth*—**IV,** pp. 124–459, 1931. *Imperial Institute, London,* Beryllium (Glucinum) and Beryl, pp. 3–20, **1931;** Lithium, pp. 1–27, **1932.** Jones, W. R., Tin fields of the world, *London,* **1925.** LaCroix, Alfred, *Mineralogie de Madagascar, Paris,* **1922.** Mohr, H., *Der Nutzglimmer, Berlin,* Gebrüder Borntraeger, pp. 1–275, **1930.** Petar, Alice V., Beryllium and beryl: *U. S. Bur. Mines, Infor. Circ.* **6190,** Nov., 1929. Spence, H. S., Mica: *Canada Dept. Mines,* no. **701,** 1929.

Maps are included (Plates I to VI) for each continent. These give the distribution of complex acidic, intermediate, and basic pegmatites. Simple acidic pegmatites are not shown. Their areas of outcrop would include most of the pre-Cambrian shield of the globe and also numerous localities where younger intrusives are exposed. The symbols used on the maps in some instances refer to single pegmatite bodies, but in most cases they are intended to include a district.

The writer appreciates that the following compilation of pegmatite localities is not a complete one. However, he does believe that most of the important pegmatites (those that have yielded specimens of economic or mineralogical interest) have been included. Beside these a large number of minor occurrences of pegmatite are mentioned. The latter are included in order to give an adequate picture of the very widespread distribution of pegmatite bodies.

The writer is grateful to the College Students Employment Project for the services of Robert Ferris as a bibliographic assistant, and to the Graduate Research Committee of the University of Kansas for a grant defraying the cost of the map cuts.

NORTH AMERICA

UNITED STATES

GENERAL REFERENCES: Hess, Frank L., The pegmatites of the western states: Ore deposits of the western states, *Am. Inst. Min.*

[37] Landes, Kenneth K., Origin and classification of pegmatites: *Am. Mineral.,* vol. **18,** pp. 33–56 and 95–103, 1933.

Engr., p. 535, **1933**. Sterrett, D. B., Mica deposits of the U. S.: *U. S. Geol. Survey, Bull.* **740**, 1923. Bastin, E. S., Economic

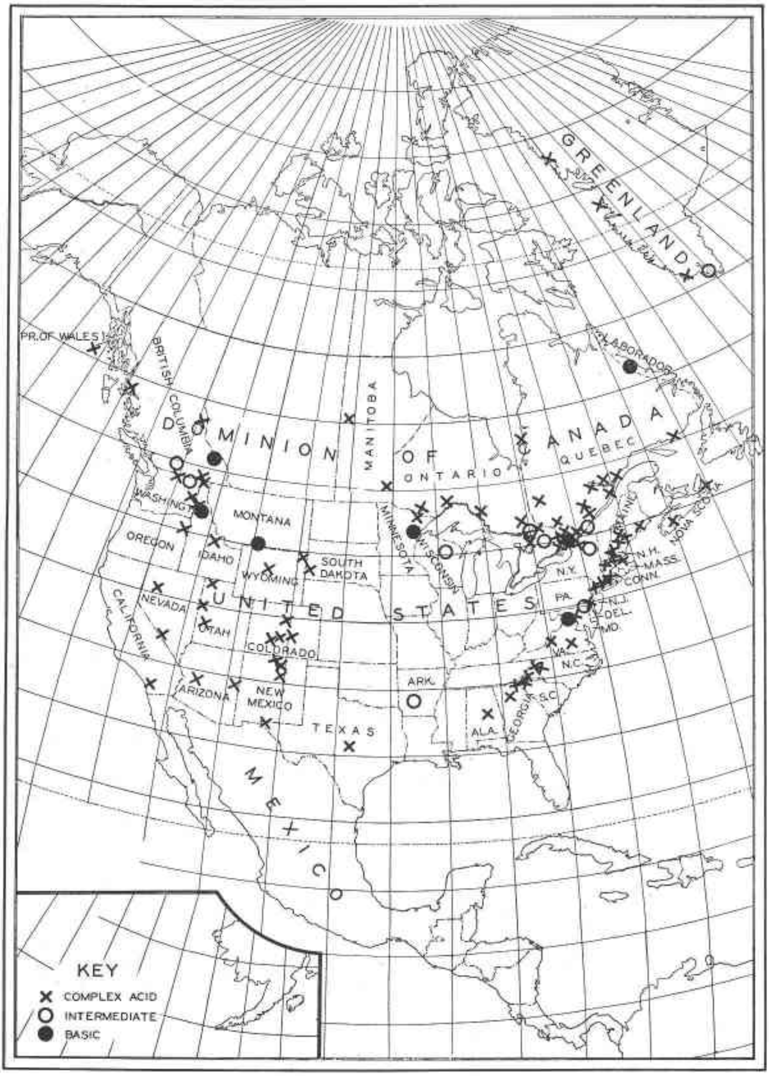

PLATE I. Distribution of complex acidic and intermediate and basic pegmatites in North America.

geology of the feldspar deposits of the United States: *U. S. Geol. Survey, Bull.* **420**, 1910.

MAINE. Principal localities: Mainly in Oxford and Androscoggin counties, but some in Sagadahoc, Kennebec, Hancock and other counties. Mount Mica, Mount Apatite, Poland, Rumford, Stoneham, Hebron, Albany, Buckfield, Greenwood, Newry, and Topsham are the more famous place names. Types of pegmatite: Granite, both simple and complex. In the latter beryllium, boron, lithium, phosphate, and fluorine (topaz) phases may be well developed.

REFERENCES: Bastin, Edson S., Geology of the pegmatites and associated rocks of Maine, including feldspar, quartz, mica and gem deposits: *U. S. Geol. Survey, Bull.* **445,** pp. 9–147, 1911. Berman, Harry, and Gonyer, F. A., Pegmatite minerals of Poland, Maine: *Am. Mineral.*, vol. **15,** pp. 375–387, 1930. Fisher, Lloyd W., and Barrell, R., Mount Apatite, Maine: *Rocks and Minerals*, vol. **9,** no. 2, pp. 13–16, Feb., 1934. Fraser, H. J., Paragenesis of the Newry pegmatite, Maine: *Am. Mineral.*, vol. **15,** pp. 349–364, 1930. Gedney, E. K., and Berman, Harry, Huge beryl crystals from Albany, Maine: *Rocks and Minerals*, vol. **4,** pp. 78–80, 1929. Landes, Kenneth K., The paragenesis of the granite pegmatites of central Maine: *Am. Mineral.*, vol. **10,** no. 11, pp. 355–411, Nov., 1925. Palache, Charles, A topaz deposit in Topsham, Maine: *Am. Jour. Sci.*, vol. **27,** pp. 37–48, 1934.

NEW HAMPSHIRE. Principal areas: Grafton and Cheshire counties; also Sullivan, Merrimack, and Hillsboro. Important localities are Grafton, Orange, Rumney, Alexandria, Acworth (and South Acworth), Sullivan, Gilsum, Alstead, Roxbury, Danbury, Baldface Mt., and Milford. Types of pegmatite: Many are granite complex, with beryllium, fluorine, and boron (tourmaline) phases. Milford pegmatite is granodiorite.

REFERENCES: Billings, Marland P., Topaz and phenacite from Baldface Mountain, Chatham, New Hampshire: *Am. Mineral.*, vol. **12,** no. 4, pp. 173–179, 1927. Dale, F. N., The granites of Massachusetts, New Hampshire, and Rhode Island: *U. S. Geol. Survey, Bull.* **354,** 1908. Megathlin, G. R., Spodumene and autunite from Alstead, New Hampshire: *Am. Mineral.*, vol. **13,** no. 12, pp. 578–579, 1928. Flint, George M., Famous mineral localities; Beryl Hill, Grafton, New Hampshire: *Am. Mineral.*, vol. **4,** no. 3, pp. 21–22, 1929. Holden, Edward F., Famous mineral localities; Beryl Mountain, Acworth, New Hampshire: *Am. Mineral.*, vol. **3,** pp. 199–200, 1918. Megathlin, G. R., The pegmatite dikes of the Gilsum area, New Hampshire: *Econ. Geology*, vol. **24,** no. 2, pp. 163–181, 1929.

VERMONT. Localities: Barre, Chester, and Robeson Mt. (Woodbury). Type: Granite simple.

REFERENCE: Dale, T. N., The granites of Vermont: *U. S. Geol. Survey, Bull.* **404,** pp. 1–138, 1909.

MASSACHUSETTS. Principal localities: Chesterfield, Goshen, Lithia, Royalston, Northfield, Uxbridge, Quincy, Winchester, Rockport (Cape Ann), and western Hampden County. Types of pegmatite: Common granite and alkaline granite (Quincy and Rockport). Some are complex with boron, lithium, beryllium, or rare earth phases. Pegmatites containing diopside intrude limestone in western Massachusetts.

REFERENCES: Browne, Betty V., A visit to the Lithia and Plainfield, Mass., localities: *Rocks and Minerals*, vol. **8**, pp. 115–116, 1933. Emerson, B. K., Northfieldite, pegmatite, and pegmatite schist: *Am. Jour. Sci.*, (4) vol. **40**, pp. 212–217, 1915. Eskola, Pentti, On contact phenomena between gneiss and limestone in western Massachusetts: *Jour. Geology*, vol. **30**, pp. 265–294, 1922. Jaggar, T. A., Jr., An occurrence of acid pegmatite in diabase: *Am. Geologist*, vol. **21**, pp. 203–213, 1898. Warren, C. H., and McKinstry, Hugh E., The granites and pegmatites of Cape Ann, Massachusetts: *Proc. Am. Acad. Arts and Science*, vol. **59**, no. 14, pp. 315–357, 1924. Warren, C. H., and Palache, Charles: The pegmatites of the riebeckite-aegirite granite of Quincy, Massachusetts, U.S.A.; their structure, minerals, and origin: *Proc. Am. Acad. Arts and Science*, vol. **47**, pp. 125–168, 1911.

RHODE ISLAND. Principal localities: Southwestern Rhode Island in the vicinity of Westerly, west coast of Narragansett Bay, and Diamond Hill. Types of pegmatite: Granite, mainly simple, and alkaline granite (Diamond Hill).

REFERENCES: Lahee, F. H., Relations of the degree of metamorphism to geologic structure and to acid igneous intrusion in the Narragansett Basin, Rhode Island: *Am. Jour. Sci.* (4), vol. **33**, pp. 249–262; 354–372; 447–469, 1912.

CONNECTICUT. Principal localities: Portland, Middletown, South Glastonbury, Haddam Neck, Trumbull, Branchville, New Milford, and Chatham. Types of pegmatite: Granite, the larger ones complex. A lithium phase is prominent at Chatham, a beryllium phase at Haddam Neck, a phosphate phase at Branchville, a fluorine phase at Trumbull, and both lithium and phosphate phases at Portland.

REFERENCES: Bowman, H. L., On an occurrence of minerals at Haddam Neck, Conn.: *Min. Mag.*, vol. **13**, pp. 97–121, 1902. Brush, G. J., and Dana, E. S., On the mineral locality at Branchville: *Am. Jour. Sci.* (3), vol. **39**, pp. 201–216, 1890. Foye, W. G., Mineral localities in the vicinity of Middletown, Connecticut: *Am. Mineral.*, vol. **7**, pp. 4–12, 1922. Schairer, J. F., The minerals of Connecticut: *Conn. Geol. and Nat. Hist. Survey, Bull.* **51**, 1931. Shannon, E. V., Strickland's quarry, Portland, Connecticut: *Am. Mineral.*, vol. **5**, no. 3, pp. 51–54, 1920. Shannon, E. V., The old lithia mine in Chatham, Connecticut: *Am. Mineral.*, vol. **5**, no. 4, pp. 82–84, 1920.

NEW YORK. Principal localities: Pierrepont, De Kalb and Gouverneur in St. Lawrence County; Saratoga and Fulton counties;

Chester, Bedford, and New York City; and many localities in the Adirondacks. Types of pegmatite: Granite, and in the Adirondacks granodiorite (or quartz-diorite) and diorite. The Fordham gneiss is thoroughly impregnated with pegmatite. The Bedford pegmatite is complex with a rare earth phase, a boron phase is present in several of the St. Lawrence County deposits, and many of the pegmatites in the Adirondacks have an iron ore (magnetite) phase.

REFERENCES: Agar, Wm. M., The pegmatites of Bedford, New York: *Sixteenth International Geol. Congress, Guidebook* **9**, pp. 123–128, 1933. Alling, Harold L., Genesis of the Adirondack magnetites: *Econ. Geology*, vol. **20**, pp. 335–363, 1925. Colony, R. J., Structural geology between New York and Schunemunk Mt.: *Sixteenth International Geol. Congress, Guidebook* **9**, pp. 19–44, 1933. Miller, Wm. J., Pegmatite, silexite, and aplite of northern New York: *Jour. Geology*, vol. 27, pp. 28–55, 1919. Newland, D. H., Structures in Adirondack magnetites: *Bull. Geol. Soc. America*, vol. **42**, p. 238, 1931. Shaub, B. M., A unique feldspar deposit near De Kalb Junction, New York: *Econ. Geology*, vol. **24**, no. 1, pp. 68–69, 1929.

NEW JERSEY. Principal localities: Abundant in the pre-Cambrian crystalline rocks composing the highlands of northern New Jersey. A minor occurrence is in the Triassic diabase of the Palisades. Types of pegmatite: Granite, in a number of localities with a magnetite phase.

REFERENCES: Bayley, W. S., Iron mines and iron mining in New Jersey: *New Jersey Survey, Final Report*, vol. **7**, 1910. Kemp, J. F., The role of the igneous rocks in the formation of veins: *Trans. Am. Inst. Min. Eng.*, vol. **31**, pp. 182–183, 1901. Palache, Charles, Paragenetic classification of the minerals of Franklin, N.J.: *Am. Mineral.*, vol. **14**, no. 1, pp. 1–18, 1929. Ries, H., and Bowen, W. C., Origin of the zinc ores of Sussex County, New Jersey: *Econ. Geology*, vol. **17**, pp. 517–571, 1922. Smith, Lawrence, L., Magnetite ores of northern New Jersey: *Econ. Geology*, vol. **28**, pp. 658–677, 1933. Spencer, A., Description of Franklin Furnace quadrangle, New Jersey: *U. S. Geol. Survey, Folio* **161**, pp. 1–27, 1908.

PENNSYLVANIA. Principal localities: Southeastern Pennsylvania, especially Chester and Delaware counties. Types of pegmatite: Simple granite, granite complex with beryllium and iron ore (magnetite) phases, and syenite pegmatite ("soda pegmatites" of Bastin) adjacent to the Maryland line.

REFERENCES: Miller, B. L., The geology of the graphite deposits of Pennsylvania: *Econ. Geology*, vol. **7**, pp. 762–777, 1912. Stone, Ralph W., and Hughes, H. Herbert, Feldspar in Pennsylvania: *Pa. Geol. Survey, 4th ser., Bull.* **M13**, pp. 7–63, 1931.

DELAWARE. Simple pegmatites occur at the northern end of the state adjacent to Pennsylvania.

REFERENCE: Bascom, F., and Stose, G. W., Coatesville and West Chester quadrangles, Pennsylvania-Delaware: *U. S. Geol. Survey, Geologic Folio* **223**, pp. 1–15, 1932.

MARYLAND. Principal localities: Montgomery, Howard and Baltimore counties, and Cecil County in the northeastern corner. Types of pegmatite: Granite, except for syenite pegmatites in Cecil County adjacent to Pennsylvania. Complex pegmatite in Montgomery County. Diopside in Howard County pegmatite due to intrusion into dolomite.

REFERENCES: Shannon, E. V., Some minerals from the Kensington mica mine, Montgomery County, Maryland: *Am. Mineral.*, vol. **11**, no. 2, pp. 35–37, 1926. Watson, E. H., A diopside-bearing pegmatite in dolomite: *Econ. Geology*, vol. **24**, no. 6, pp. 611–625, 1929. Williams, G. H., Origin of the Maryland pegmatites: *U. S. Geol. Survey, 15th Ann. Rept.*, pp. 675–685, 1895. Williams, G. H., The gabbros, etc., in the neighborhood of Baltimore, Maryland: *U.S. Geol. Survey, Bull.* **28**, 1886.

VIRGINIA. Principal localities: East-central Virginia, especially Amelia, Goochland, and Hanover counties; west-central Virginia, especially Rockbridge, Amherst and Henry counties, and Loudoun County in northern Virginia. Types of pegmatite: Granite, many of them complex with titanium, zirconium, and rare earth phases prominent. Kyanite occurs in pegmatite in southwestern Virginia. Diabase pegmatites of Triassic age occur in Loudoun County.

REFERENCES: Jonas, A. I., and Watkins, J. H., Kyanite in Virginia: *Virginia Geol. Survey, Bull.* **38**, pp. 1–52, 1932. Lonsdale, John T., Geology of the gold-pyrite belt of the northeastern piedmont, Virginia: *Virginia Geol. Survey, Bull.* **30**, pp. 1–110, 1927. Pegau, A. A., Pegmatite deposits of Virginia: *Virginia Geol. Survey, Bull.* **33**, pp 1–123, 1932. Ross, C. S., Titanium deposits of Roseland district: *Sixteenth International Geol. Congress, Guidebook* **11**, pp. 29–36, 1933. Shannon, E. V., The mineralogy and petrology of intrusive Triassic diabase at Goose Creek, Loudoun County, Virginia: *Proc. U. S. Nat. Mus.*, vol. **66**, art. 2, 1924. Watson, T. L., Zircon-bearing pegmatites in Virginia: *Trans. Am. Inst. Min. Eng.*, vol. **55**, pp. 936–942, 1917. Watson, T. L., and Taber, S., Geology of the titanium and apatite deposits of Virginia: *Virginia Geol. Survey, Bull.* **3A**, pp. 1–308, 1913.

NORTH CAROLINA. Principal localities: Pre-Cambrian crystalline rock area toward the western end of the state, especially in Alexander, Cleveland, Burke, Mitchell, Yancey, Avery, Haywood, Macon, and Jackson counties. Types of pegmatite: Granite simple and complex. Latter exhibit the following phases: rare earth (especially at Spruce Pine), magnetite (Cranberry), tin, and beryllium (producing common beryl, aquamarine, and emerald).

Kyanite and hiddenite are unusual pegmatite minerals found in North Carolina.

REFERENCES: Bayley, W. S., Magnetic iron ores of eastern Tennessee and western North Carolina: *North Carolina Geol. and Econ. Survey, Bull.* **32,** pp. 1–252, 1923. Hall, George M., Zoisite and other minerals included in mica from Spruce Pine, North Carolina: *Am. Mineral.*, vol. **19,** no. 2, pp. 76–80, 1934. Keith, Arthur, Gaffney-Kings Mountain Folio, South and North Carolina: *U. S. Geol. Survey, Geologic Folio* **222,** 1931. Palache, Charles, Davidson, S. C., and Goranson, E. A., The hiddenite deposit in Alexander County, North Carolina: *Am. Mineral.*, vol. **15,** pp. 280–302, 1930. Schaller, W. T., A large monazite crystal from North Carolina: *Am. Mineral.*, vol. **18,** no. 10, pp. 435–439, 1933. Stuckey, J. L., Cyanite deposits of North Carolina: *Econ. Geology*, vol. **27,** no. 7, pp. 661–674, 1932.

SOUTH CAROLINA. Principal localities: The extreme western part of the state, especially Anderson and Greenville counties. Types of pegmatite: Granite, with a beryllium phase in Anderson County.

REFERENCE: Keith, Arthur, Gaffney-Kings Mt. Folio, South and North Carolina: *U. S. Geol. Survey, Geol. Folio* **222,** 1931.

GEORGIA. Principal localities: Pegmatites are widely scattered through at least 20 counties in the crystalline rock belt of Georgia which covers most of the northern half of the state. Types of pegmatite: Granite, mostly simple. Beryl occurs in pegmatite in Rabun County.

REFERENCES: Galpin, S. L., A preliminary report on the feldspar and mica deposits of Georgia: *Georgia Geol. Survey, Bull.* **30,** 1915. Watson, T. L., On the occurrence of aplite, pegmatite and tourmaline bunches in the Stone Mountain granite of Georgia: *Jour. Geology*, vol. **10,** pp. 186–193, 1902.

ALABAMA. Principal localities: In east-central Alabama, mainly Randolph, Clay, Tallapoosa, and Coosa counties. Types of pegmatite: Mostly granite simple. Beryllium phase in Randolph and Coosa counties.

REFERENCES: Brown, J. S., Graphite deposits of Ashland, Alabama: *Econ. Geology*, vol. **20,** p. 224, 1925. Van Horn, F. R., Occurrence of a large iron-tourmaline in Alabama pegmatites: *Am. Mineral.*, vol. **10,** no. 10, pp. 348–350, 1925.

TEXAS. Principal localities: Culberson and El Paso counties in western Texas, and Baringer Hill and adjacent pegmatites in Llano and Mason counties in the Central Mineral Region. Types of pegmatite: Granite, with a rare earth phase in the Baringer Hill neighborhood and a tin phase in the Franklin Mountains in El Paso County.

REFERENCES: Hess, F. L., Minerals of the rare-earth metals at Baringer Hill, Llano County, Texas: *U. S. Geol. Survey, Bull.* **340,** pp. 286–294, 1908. Landes, K. K., The

Baringer Hill, Texas, pegmatite: *Am. Mineral.*, vol. **17,** no. 8, pp. 381–390, 1932. Paige, S., Description of Llano and Burnet quadrangles: *U. S. Geol. Survey, Folio* **183,** 1912.

ARKANSAS. Locality: Magnet Cove. Type of pegmatite: Nephelite-syenite with rare alkaline mineral phase.

REFERENCES: Landes, K. K., A paragenetic classification of the Magnet Cove minerals: *Am. Mineral.*, vol. **16,** no. 8, pp. 313–326, 1931. Williams, J. F., Igneous rocks of Arkansas: *Arkansas Geol. Survey, Ann. Rept.*, vol. **11,** 1890.

OKLAHOMA. Locality: Pre-Cambrian crystalline rock exposure in Wichita Mountains, southwestern Oklahoma. Types of pegmatite: Alkaline granite (Greer County) and zircon pegmatite near Indiahoma.

REFERENCE: Rogers, A. F., Aegirite and riebeckite rocks from Oklahoma: *Jour. Geology*, vol. **12,** pp. 283–287, 1907.

MISSOURI. Locality: Camden County, western Missouri. Type of pegmatite: Granite, simple.

REFERENCE: Gould, Charles N., Crystalline rocks of the plains: *Bull. Geol. Soc. America*, vol. **34,** pp. 541–560, Sept., 1923.

MICHIGAN. Pegmatite localities: Pre-Cambrian portion of the upper peninsula. Type of pegmatite: Granite, simple.

REFERENCES: Lamey, C. A., The intrusive relations of the Republic granite: *Jour. Geology*, vol. **41,** no. 5, p. 490, 1933. Van Hise, C. R., Treatise on metamorphism: *U. S. Geol. Survey, Mon.* **47,** p. 725, 1904.

WISCONSIN. Pegmatite localities: Pre-Cambrian area of north central Wisconsin. Types of pegmatite: Granite and nephelite-syenite.

REFERENCE: Weidman, S., The geology of north-central Wisconsin: *Wisconsin Geol. and Nat. Hist. Survey, Bull.* **16,** pp. 1–697, 1907.

MINNESOTA. Pegmatite localities: Pre-Cambrian area, especially the northern part of the state. Types of pegmatite: Granite, some with a magnetite phase, and gabbro in the vicinity of the Duluth gabbro.

REFERENCES: Grout, F. F., Magnetite pegmatites of northern Minnesota: *Econ. Geology*, vol. **18,** pp. 253–269, 1923. Grout, F. F., The pegmatites of the Duluth gabbro: *Econ. Geology*, vol. **13,** pp. 185–197, 1918. Grout, F. F., Contact metamorphism of the slates of Minnesota by granite and by gabbro magmas: *Bull. Geol. Soc. America.*, vol. **44,** no. 5, pp. 989–1040, 1933.

SOUTH DAKOTA. Principal localities: Confined to the pre-Cambrian area of the Black Hills, especially the vicinities of Keystone and Custer. Types of pegmatite: Granite simple and complex, with strong lithium phase and less marked beryllium and tin ore phases in several.

REFERENCES: Connolly, J. P., and O'Harra, C. C., The mineral wealth of the Black Hills: *South Dakota School of Mines, Bull.* **16,** pp. 1–418, 1929. Darton, N. H., and Paige, Sidney, Central Black Hills folio, South Dakota: *U. S. Geol. Survey, Folio* **219.** Hess, Frank L., Tin, tungsten, and tantalum deposits of South Dakota: *U. S. Geol. Survey, Bull.* **380,** pp. 131–161, 1909. Hess, Frank L., The natural history of the pegmatites: *Eng. and Min. Jour.,* vol. **120,** no. 8, pp. 289–298, Aug. 22, 1925. Landes, Kenneth K., Sequence of mineralization in the Keystone, South Dakota, pegmatites: *Am. Mineral.,* vol. **13,** pp. 519–530; 537–558, Oct., Nov., 1928. Schwartz, G. M., Geology of the Etta spodumene mine, Black Hills, South Dakota: *Econ. Geology,* vol. **20,** pp. 646–659, 1925. Schwartz, G. M., The Tin Mt. spodumene mine, Black Hills, South Dakota: *Econ. Geology,* vol. **25,** no. 3, pp. 275–284, 1930. Ziegler, V., The minerals of the Black Hills: *South Dakota School of Mines, Bull.* **10,** 1914.

MONTANA. Principal localities: Associated with the intrusive rocks in the western part of the state. Types of pegmatite: Granite (simple) and basic.

REFERENCES: Barrell, Joseph., Geology of Marysville mining district, Montana: *U. S. Geol. Survey, Prof. Paper* **57,** pp. 1–178, 1907. Emmons, W. H., Geology of the Haystack stock, Cowles, Park County, Montana: *Jour. Geology,* vol. **16,** pp. 193–229, 1908. Lovering, T. S., Magmatic chalcopyrite, Park County, Montana: *Econ. Geology,* vol. **19,** pp. 636–640, 1924. Weed, W. H., and Barrell, J., Geology and ore deposits of the Elkhorn mining district, Jefferson County, Montana: *U. S. Geol. Survey, 22nd* Ann. Rept., pt. **2,** pp. 399–550, 1901. Winchell, A. N., A theory for the origin of graphite as exemplified in the graphite deposit near Dillon, Montana: *Econ. Geology,* vol. **6,** pp. 218–230, 1911.

WYOMING. Principal localities: Widely scattered in the pre-Cambrian areas of Laramie, Albany, and Carbon counties in the southeastern part of the state, in northern Fremont County in west-central Wyoming, and along the eastern edge of Crook County in the northeast corner where the Black Hills extend into Wyoming. Types of pegmatite: Granite, mainly simple. Fremont County pegmatites are complex, containing lithium minerals and beryl, and Crook County pegmatites contain cassiterite.

REFERENCES: Ball, Sidney H., Mica in the Hartville Uplift, Wyoming: *U. S. Geol. Survey, Bull.* **315,** pp. 423–428, 1906. Swartzlow, Carl R , *Personal communication,* Jan. 3, 1934.

COLORADO. Principal localities: In practically every county in the Front Range extending from the Wyoming line south to Fremont County in south central Colorado and in pre-Cambrian areas to the westward. Types of pegmatite: Mainly granite and quartz monzonite. A fluorine phase is well developed in the Pikes Peak-St. Peter's Dome region. Ore mineral phases occur in Boulder County and in the Georgetown district (magnetite). A newly-described pegmatite near Ohio City in the Gunnison Valley exhibits a strong lithium phase. A beryllium phase is important at Mount Antero and elsewhere in the upper Arkansas River valley.

REFERENCES: Eckel, Edwin B., A new lepidolite deposit in Colorado: *Jour. Am. Ceramic Soc.*, vol. **16,** no. 5, pp. 239–245, May, 1933. Lindgren, W., Some gold and tungsten deposits of Boulder County, Colorado: *Econ. Geology*, vol. **2,** pp. 453–463, 1907. Palache, C., and Over, Edwin, Jr., Pegmatites of the Pikes Peak region, Colorado: Abstract, *Am. Mineral.*, vol. **18,** p. 115, 1933. Spurr, J. E., and Garrey, G. H., Preliminary report on the ore deposits in the Georgetown, Colorado, mining district: *U.S. Geol. Survey, Bull.* **260,** 1905; *U.S. Geol. Survey, Prof. Paper* **63,** p. 60 et seq.

NEW MEXICO. Principal localities: In north-central New Mexico on both sides of the county line separating Rio Arriba and Taos counties and southeastward into Mora and San Miguel counties. Types of pegmatite: Granite simple, and complex with a rare earth phase near Petaca, Rio Arriba County, a lithium phase in the vicinity of Embudo in Taos County, and a molybdenite phase near Porvenir in San Miguel County.

REFERENCES: Hess, F. L., and Wells, R. C., Samarskite from Petaca, New Mexico: *Am. Jour. Sci.*, vol. **19,** no. 109, pp. 17–26, Jan., 1930. Horton, F. W., Molybdenite, its ores and their concentration: *U. S. Bur. Mines, Bull.* **111,** p. 78, 1916. Roos, Alford, Mining lepidolite in New Mexico: *Eng. and Min. Jour.*, vol. **121,** no. 26, pp. 1037–1042, 1926. Schaller, W. T., and Henderson, E. P., Purple muscovite from New Mexico: *Am. Mineral.*, vol. **11,** pp. 5–15, 1926.

ARIZONA. Principal localities: Central Arizona, and the Archean rocks of the Inner Gorge of Colorado River. Types of pegmatite: Granite, mostly simple. Complex with phosphate phase near Hillside in west-central Arizona. Tungsten ore (wolframite) phase at Cave Springs in east-central Arizona.

REFERENCES: Bastin, E. S., Primary native silver ores near Wickenburg, Arizona: *U.S. Geol. Survey, Bull.* **735,** pp. 131–155, 1922. Campbell, I., and Maxson, J. H., Some observations on the Archean metamorphics of the Grand Canyon: *Proc. Nat. Acad. Sci.*, vol. **19,** no. 9, pp. 806–809, Sept., 1933. Hurlburt, C. S., Jr., and Gonyer, F. A., New group of phosphates: *Geol. Soc. America*, Proc. for 1933, p. 440, 1934. Lausen, Carl. Tourmaline-bearing cinnabar veins of the Mazatzal Mountains, Arizona: *Econ. Geology*, vol. **21,** pp. 782–791, Dec., 1926.

UTAH. Principal localities: Park Valley district in northwestern Utah; Deep Creek Mountains south of Gold Hill in west-central Utah; and Beaver and San Francisco ranges in southwestern Utah.

Types of pegmatite: Granite and quartz monzonite. Complex with ore mineral phase at Park Valley, Spring Creek (Deep Creek Mountains), and Beaver Lake. Beryl also present in Deep Creek Mountains.

REFERENCE: Butler, B S., Ore deposits of Utah: *U. S. Geol. Survey, Prof. Paper* **111,** p. 159, 1920.

IDAHO. Principal localities: In and surrounding the great batholith of north-central Idaho, especially in Latah County, and in Cassia County in southern Idaho. Types of pegmatite: Granite, mainly simple. Some beryl is found in the Latah County deposits and molybdenite occurs in pegmatites in Boundary and Lemhi counties. A hornblendite pegmatite has been found in western Clearwater County.

REFERENCES: Anderson, A. L., Genesis of mica pegmatite deposits, Latah County, Idaho: *Econ. Geology,* vol. **28,** no. 1, pp. 41–58, 1933. Anderson, A. L., Geology and mineral resources of eastern Cassia County, Idaho: *Idaho Bur. Mines and Geology, Bull.* **14,** pp. 1–164, 1931. Anderson, A. L., An occurrence of giant hornblendite: *Jour. Geology,* vol. **41,** no. 1, pp. 89–98, 1933 Livingston, D. C., Tungsten, cinnabar, manganese, molybdenum, and tin deposits of Idaho: *Univ. of Idaho School of Mines,* vol. **14,** Bull. 2, pp. 40–41, 1919. Shannon, E. V., Note on garnet from a pegmatite in Idaho: *Am. Mineral.,* vol. **7,** pp. 171–173, 1922. Thomson, F. A., and Ballard, S. M., Geology and gold resources of north-central Idaho: *Idaho Bur. Mines and Geology,* vol. **7,** p. 34, 1924.

NEVADA. Principal localities: A few widely scattered pegmatites have been reported from the southeastern (northeastern Clark County) and southwestern (especially Bullfrog Hills) parts of the state and from the Rochester mining district in northwest central Nevada. Types of pegmatite: Granite, with a gold phase in the Rochester district and a molybdenite phase n southwestern Nevada

REFERENCES: Ball, Sydney H., The post-Jurassic igneous rocks of southwestern Nevada: *Jour. Geology,* vol. **16,** pp. 36–45, 1908. Knopf, A., Geology and ore deposits of the Rochester district, Nevada: *U. S. Geol. Survey, Bull.* **762,** pp. 1–78, 1924

CALIFORNIA. Principal localities: Pegmatites have been reported from about 14 counties scattered over northern, east-central, and southern California. The most important district is in Riverside and San Diego counties in southern California. Types of pegmatite: Granodiorite simple in Sierra Nevada ranges in east-central and northern California. Granite complex in San Diego and Riverside counties with a very prominent lithium phase.

Other phases present are boron (tourmaline), beryllium, molybdenum, and rare earth (monazite).

REFERENCES: Calkins, F. C., Molybdenite near Ramona, San Diego County, California: *U. S. Geol. Survey, Bull.* **640-D**, pp. 73–76, 1916. Dykes, Leland H., Occurrence of monazite in a granodiorite pegmatite in Riverside County, California: *Bull. Geol. Soc. America*, vol. **44**, pt. 1, p. 161, 1933. Eakle, A. S., Minerals associated with the crystalline limestone at Crestmore, Riverside County, California: *Univ. California, Geol. Bull.* **10**, pp. 327–360, 1917. Hess, F. L., Some molybdenite deposits of Maine, Utah, and California: *U. S. Geol. Survey, Bull.* **340**, pp. 231–240, 1908. Hudson, F. S., Geology of the Cuyamaca region of California: *Univ. of Calif., Pub. in Geology*, vol. **13**, no 6, pp. 175–252, June, 1922. Rogers, A. F., Minerals from the pegmatite veins of Rincon, San Diego County, California: *School of Mines, Quart.*, vol. **31**, pp. 208–218, 1910. Schaller, W. T., The genesis of lithium pegmatites: *Am. Jour. Sci.*, vol. **10**, pp. 269–279, Sept., 1925. Waring, G. A., The pegmatite veins of Pala, San Diego County, California: *Am. Geologist*, vol. **35**, pp. 356–369, 1905.

OREGON. Locality: Wallowa Mountains in the northeastern part of the state. Type of pegmatite: Granodiorite.

REFERENCE: Goodspeed, G. E., Certain pegmatite facies of the Wallowa Mountains batholith in northeastern Oregon: *Bull. Geol. Soc. America*, vol. **44**, pt. 1, p. 160, 1933.

WASHINGTON. Principal localities: Silver Hill, near Spokane, Ferry and Okanogan counties in the northeastern part of the state, Chelan County in north-central Washington, and Bald Butte Ridge in southeastern Washington. Types of pegmatite: Mainly granite simple. The Silver Hill pegmatite is complex with a tin phase and molybdenite-bearing pegmatites occur in central and northern Okanogan County. The pegmatites in northern Ferry County are complex syenite with a copper sulphide phase.

REFERENCES: Anderson, A. L., Genesis of Silver Hill tin deposits: *Jour. Geology*, vol. **36**, pp. 646–664, Oct.–Nov., 1928. Hoffman, Malvin, G., The geology of Bald Butte Ridge, Washington: *Jour. Geology*, vol. **40**, no. 7, pp. 634–650, 1932. Horton, F. W., Molybdenite; its ores and their concentration: *U. S. Bur. Mines, Bull.* **111**, p. 78, 1916. Jones, E. L., Jr., Reconnaissance of the Conconully and Ruby mining districts, Washington: *U. S. Geol Survey, Bull.* **640**, pp. 11–36, 1916. McLaughlin, D. H , Copper sulphides in syenite and pegmatite dikes: *Econ Geology*, vol. **14**, no 5, pp. 403–410, 1919. Richarz, Stephen, Peculiar gneisses and ore formations in the eastern Cascades, Washington: *Jour. Geology*, vol. **41**, no 7, pp. 757–768, 1933. Waters, A. C., A petrologic and structural study of the Swakane gneiss, Entiat Mountains, Washington: *Jour. Geology*, vol. **40**, no. 7, pp. 604–633, 1932.

ALASKA. Principal localities: In Coast Range intrusives in southeastern Alaska and widely scattered occurrences in the interior. Types: Granite simple mainly. Complex with sulphide phase at Shakan, southeastern Alaska.

REFERENCES: Brooks, A. H., Reconnaissance in the Tanana and White River basins, Alaska, in 1898: *U. S. Geol. Survey*, **20**th Ann. Rept., pt. 7, pp. 425–494, 1898–99. Brooks, A. H., Preliminary report on the Ketchikan district, Alaska: *U. S. Geol. Survey, Prof. Paper* **1**, 1902. Buddington, A. F., Molybdenite deposit at Shakan, Alaska: *Econ. Geology*, vol. **25**, no. 2, pp. 197–200, 1930. Buddington, A. F., Coincident variations of types of mineralization of Coast Range intrusives: *Econ. Geology*, vol **22**, pp. 158–179, 1927. Spurr, J. E., Geology of the Yukon District, Alaska: *U. S. Geol. Survey*, **18**th Ann. Rept., pt. 3, pp 1–392, 1896–97.

CANADA

GENERAL REFERENCES: Eardley-Wilmot, V. L., Molybdenum: *Canada Dept. Mines, Mines Branch*, no. **592**, pp. 1–292, 1925. Ellsworth, H. V., Rare element minerals of Canada: *Canada Geol. Survey, Econ. Geology Ser.* no. **11**, pp. 1–272, 1932. Gwillim, J. C., Molybdenite in Nova Scotia, Quebec, Ontario, and British Columbia: *Munition Resources Commission, Canada, Final Rept.*, pp. 104–133, **1920**. Spence, H. S., Notes on beryllium and beryl: *Canada Dept. Mines, Mines Branch, Memo. Ser.* no. **40**, pp. 1–16, April, 1930. Spence, Hugh S., Pegmatite minerals of Ontario and Quebec: *Am. Mineral.*, vol. **15**, no. 9, pp. 430–450; 474–495, 1930. Spence, Hugh S., Feldspar: *Canada Dept. Mines, Mines Branch*, no. **731**, pp. 1–145, 1932. Walker, T. L., Molybdenite ores of Canada: *Canada Dept. Mines, Mines Branch*, no. **93**, pp. 1–64, 1911. Young, G. A., Geology and economic minerals of Canada: *Canada Geol. Survey*, no. **2065**, 1926.

NEWFOUNDLAND, LABRADOR, AND BAFFIN ISLAND. Principal localities: Widely scattered over pre-Cambrian shield; also in ultrabasic rocks of Labrador coast. Types: Granite simple; pure labradorite pegmatites in Labrador.

NOVA SCOTIA. Principal localities: Lunenburg (especially New Ross), Halifax, and Cape Breton counties. Type: Granite. Complex pegmatites with lithium and ore mineral phases occur in Lunenburg County and a molybdenite phase is found near Cape Breton.

REFERENCES: Cook, C. W., Molybdenite deposit near New Ross, Nova Scotia: *Econ. Geology*, vol. **20**, pp. 185–188, 1925. Davison, E. H., Tin lodes in Nova Scotia: *Mining Mag.*, vol. **42**, no. 1, pp. 20–23, 1930. Faribault, R., Lunenburg County, Nova Scotia: *Geol. Survey Canada, Summary Rept. for* **1907**, pp. 78–83, 1908.

Walker, T. L., and Parsons, A. L., Pegmatite minerals from New Ross, Nova Scotia: *Univ. Toronto Studies, Geol. Ser.* no. **17**, pp. 46–50, 1924.

QUEBEC. Principal localities: Widely scattered over the great pre-Cambrian shield; and in the Paleozoic intrusives of Mount Royal, Montreal. Pegmatites are especially abundant in the Abitibi region of southwestern Quebec, in a 100-mile wide strip north of Ottawa River between Calumet Island and Montreal, and north of St. Lawrence River and Gulf of St. Lawrence between Quebec and the east end of the Saguenay district. Types of pegmatite: Mainly granite simple and complex. Latter exhibit an important molybdenite phase at Kewagama Lake and elsewhere in Abitibi district, northwest of Ottawa in Hull-Quyon area, along south shore of Lake St. John, and in the Saguenay district near the mouth of Manikuagan River and at Romaine. A rare earth phase occurs in pegmatites near Wakefield (northwest of Hull), Buckingham, in Berthier County north of Montreal, north of Murray Bay (northeast of Quebec), and at several localities in Chicoutimi County east of Lake St. John. Beryllium phases are found in Abitibi district and 100 miles north of Montreal (chrysoberyl). Graphite occurs in pegmatite at Louisa, north of Lachute, and lithium minerals at Wakefield and on Walrus Island, Paint Hills group, James Bay. The pegmatites at Mount Royal are nephelite syenite. Basic pegmatites exhibiting a phlogopite-apatite phase occur north of Ottawa.

REFERENCES: Bain, G. W., Graphite deposits of Louisa, Quebec: *Econ. Geology*, vol. **24**, pp. 733–752, Nov. 1929. Camsell, C., Molybdenite deposits of the Moss Mine, Quyon, Quebec: *Canada Geol. Survey, Summary Rept.*, pp. 207–208, **1916.** Ellsworth, H. V., Thucholite and uraninite from the Wallingford Mine near Buckingham, Quebec: *Am. Mineral.*, vol. **13**, no. 8, pp. 442–448, 1928. Evans, Nevil N., Chrysoberyl from Canada: *Am. Jour. Sci.*, vol. **19**, pp. 316–318, 1905. Finley, F. L., The nephelite-syenites and pegmatites of Mount Royal, Montreal, Quebec: *Canadian Jour. Research*, vol. **2**, pp. 231–248, 1930. Hawley, J. E., Molybdenite deposits of La Corne township, Abitibi County: *Quebec Bur. Mines, Ann. Rept. for* **1930**, pp. 97–122, 1931 (Part C). Thomson, E., A pegmatite origin for molybdenite ores: *Econ. Geology*, vol. **13**, pp. 302–313, 1918.

ONTARIO. Principal localities: Widespread over province, but exceedingly abundant in broad belt extending eastward from Sudbury and Georgian Bay to the provincial boundary. Types of pegmatite: Alaskite simple, granite simple and complex, syenite and nephelite syenite simple and complex, and basic complex. Phases present in complex granite pegmatites: Molybdenite in Frontenac, Renfrew, and Haliburton counties, and Lake Superior and Kenora districts; beryl in Renfrew County and Nipissing and Rainy River districts; rare earth (especially radioactive minerals) in Carleton, Lanark, Renfrew, Hastings and Haliburton counties, and Nipissing, Parry Sound and Sudbury districts; calcite in Hastings and Haliburton counties; lithium in Lanark County; and iron ore in Rainy River district. Syenite (and nephelite syenite) pegmatites occur in Frontenac, Renfrew, and Hastings counties and along French River in the Parry Sound district. These exhibit a corundum phase in Renfrew and Hastings counties. Basic pegmatites have been found near Wilberforce in Haliburton County and in the phlogopite-apatite district of southeastern Ontario.

REFERENCES: Adams, Frank D., and Barlow, Alfred E., Geology of the Haliburton and Bancroft areas, Province of Ontario: *Canada Geol. Survey, Memoir* **6,** pp. 139–147, 1910. Barlow, Alfred E., Corundum, its occurrence, distribution, exploitation and uses: *Canada Geol. Survey, Dept. of Mines, Memoir* **57,** pp. 1–354, 1915. Ellsworth, H. V., Radium-bearing pegmatites of Ontario: *Geol. Survey Canada, Summary Rept.*, Pt. D, **1921.** Ellsworth, H. V., Recent discoveries of radioactive minerals in Ontario: *Canada Geol. Survey, Summary Report*, Pt. CI, **1923.** Miller, Willet G., Uranium minerals in Haliburton district, Ontario: *Canadian Min. Jour.*, p. 44, Jan. 11, **1924.** Parsons, A. L., Molybdenite deposits of Ontario: *Ontario Bur. Mines, Ann. Rept.* **26,** pp. 275–313, 1917. Sine, F. L., The pegmatite dikes of southeastern Ontario: *Canadian Min. Jour.*, vol. **47,** no. 7, pp. 169–171, Feb. 12, 1926; vol. **47,** no. 10, pp. 237–243, March 5, 1926; vol. **47,** no. 11, pp. 257–262, Mar. 12, 1926. Spence, Hugh S., and Carnochan, R. K., The Wilberforce radium occurrence: *Canadian Min. and Met., Bull.* **23,** pp. 649–688, 1930. Walker, T. L., and Parsons, A. L., Beryl and associated minerals from Lyndoch township, Renfrew County, Ontario: *Univ. Toronto Studies, Geol. Ser. no.* **24,** pp. 12–14, 1927. Walker, T. L., and Parsons, A. L., Apatite, lepidomelane, and associated minerals from Faraday township, Hastings County, Ontario: *Univ. Toronto Studies, no.* **22,** pp. 20–25, 1926. Walker, T. L., and Parsons, A. L., Minerals from the new nepheline syenite area, French River, Ontario: *Univ. Toronto Studies, no.* **22,** pp. 5–14, 1926. Wilson, M. E., Molybdenite in the lower Ottawa Valley: *Canada Geol. Survey, Summary Rept.*, Part E, pp. 19–44, **1920** (for 1919).

MANITOBA. Principal localities: Southeastern and northwestern (between Wekuska Lake and Saskatchewan line) portions of province. Types: Granite simple and complex, and a few diorite pegmatites in northwestern Manitoba. Phases in complex granite pegmatites are lithium, beryl, tin, molybdenite, and rare earth minerals, all in southeastern Manitoba, and sulphide ore phase in northwestern Manitoba.

REFERENCES: Bruce, E. L., Molybdenite near Falcon Lake, Manitoba: *Canada Geol. Survey, Summary Rept.*, Pt. D, pp. 22–25, **1917.** De Lury, J. S., Tin prospects in Manitoba: *Canadian Min. Jour.*, vol. **50**, no. 35, pp. 810–813, 1929. De Lury, J. S., Beryl in Manitoba: *Canadian Min. Jour.*, vol. **51**, no. 43, pp. 1015–1018, Oct. 24, 1930. De Lury, J. S., and Ellsworth, H. V., Uraninite from the Huron claim, Winnipeg River area, southeastern Manitoba: *Am. Mineral.*, vol. **16**, no. 12, pp. 569–575, 1931. Derry, D. R., The genetic relationships of pegmatites, aplites, and tin veins: *Geol. Mag.*, vol. **68**, no. 808, pp. 454–475, 1931. Stockwell, C. H., Geology and mineral deposits of a part of southeastern Manitoba: *Canada Geol. Survey, Mem.* **169**, 1932. Wallace, R. C., Relationships in mineral deposits in northwestern Manitoba: *Econ. Geology*, vol. **20**, pp. 431–434, 1925. Wright, J. F., Geology and mineral deposits of a part of northwestern Manitoba: *Can. Geol. Survey, Summary Rept.* **1930**, Pt. C, pp. 1–124, 1931.

SASKATCHEWAN. Simple granite pegmatites are fairly numerous in parts of northeastern Saskatchewan.

REFERENCE: Wright, J. F., *Canada Geol. Survey, Summary Rept.* **1932**, p. 90 C.

BRITISH COLUMBIA. Principal localities: Widely scattered over eastern and southern British Columbia and in northern British Columbia near Fort Grahame and on the coast in the neighborhood of Douglas Channel. Types: Granite simple and complex, monzonite complex, and basic complex. Complex granite pegmatites with a molybdenite phase occur south of Salmo and west of Nelson (Molly mine). A beryl phase is found near Tete Jaune and rare earth minerals occur in a basic pegmatite on Moose Creek, southeast of Leauchoil. A copper sulphide ore phase has been observed in pegmatites on the shores of Douglas Channel and at Copper Mountain in the Yale district. The latter pegmatite is a monzonite in composition.

REFERENCES: Catherinet, Jules, Copper Mountain, British Columbia: *Eng. and Min. Jour.*, vol. **79**, no. 3, pp. 125–127, Jan. 19, 1905. Dolmage, Victor, Finlay River district, British Columbia: *Canadian Min. Jour.*, vol. **50**, no. 8, pp. 164–168, no. 10, pp. 214–217, 229, 1929. Dolmage, Victor, Coast and islands of British Columbia between Burke and Douglas Channels: *Canada Geol. Survey, Summary Rept.*, Pt. A, pp. 35–37, **1921.** Ellsworth, H. V., and Walker, J. F., Knopite and magnetite occurrence, Moose Creek, southeastern British Columbia: *Canada Geol. Survey, Summary Rept.*, Pt. A, **1925.**

GREENLAND

Localities: Mainly on south and west coasts. Types: Granite and alkaline syenite. Complex with molybdenite phase near Egedesminde and Sydproven. Rare earth mineral phase present in Julianehaab district (in soda syenite pegmatites) and at Kara Akimgirait (East Greenland) and Kikertak (Upernivik district). Graphite-bearing pegmatites occur on Lango (Long) Island. The famous cryolite deposit of Ivigtut is considered to be a pegmatite in which the fluorine phase is so strongly developed that cryolite has been substituted for feldspar.

REFERENCES: Baldauf, R., and Beck, R., Ueber das Kryolith-Vorkommen in Grönland: *Zeitschr. prakt. Geol.*, vol. **18**, pp. 432–446, 1910. Ball, Sydney, H., The mineral resources of Greenland: *Med. om Groenland*, vol. **63**, pp. 1–60, 1922. Gordon, S. H., Mining cryolite in Greenland: *Eng. and Min. Jour.-Press*, vol. **121**, pp. 236–240, Feb. 6, 1926.

MEXICO

Localities: Muscovite has been intermittently mined from a number of pegmatites in Lower California and Sonora. Type: Probably granite simple.

GUATEMALA

Localities: Departments of El Quiche and Baja Verapaz. Types: Muscovite pegmatites, probably granite simple.

SOUTH AMERICA

GENERAL REFERENCES: Miller, B. L., and Singewald, J. T., Jr., *Mineral deposits of South America*, New York, **1919**. Gerth, H., *Geologie Südamerikas*, Berlin, **1932**.

BRAZIL. Principal localities: Scattered through ancient crystalline rocks of Minas Geraes, Bahia, Goyaz, and Sao Paulo. Types: Granite simple and complex. Former are very widespread and have been the source of commercial mica in all four provinces. Complex pegmatites are found in greatest abundance in Minas Geraes and Bahia. A zone crossing the two provinces 600 miles long and 100 miles wide parallel to the coast and about 50 miles inland contains pegmatites with a prominent beryllium phase. Some of the beryl localities are S. Anna de Onca, Glycerio (near Rio de Janeiro), and Esmeralda and Bom Jesus dos Meiros (emeralds). Brazil is a most important tourmaline producer, mainly from pegmatites at Lajao, Minas Geraes. A fluorine phase occurs on the island of Pescaria (south of Rio de Janeiro) and at Piracicabo, Minas Geraes. Gold occurs in pegmatites at Passagem. At the following localities the pegmatites exhibit a radioactive mineral phase: Santa Clara do Pomba, Divino de Ubá, São Sebastião de Correntes, Palmeira de São Jose da Lagoa, São Jose de Brejauba de Ferros.

PLATE II. Distribution of complex acidic pegmatites in South America.

REFERENCES: Branner, J. C., Outlines of the geology of Brazil to accompany the geologic map of Brazil: *Bull. Geol. Soc. America*, vol. **30**, pp. 189–338, 1919. Derby, Orville A., On the mineralization of the gold-bearing lode of Passagem, Minas

Geraes, Brazil: *Am. Jour. Sci.*, 4th ser., vol. **32,** pp. 185–190, 1911. Fenner, C. N., Radioactive minerals from Divino de Ubá, Brazil: *Am. Jour. Sci.*, 5th ser., vol. **16,** pp. 382–391, 1928. Moraes, Luciano J., Beryllium minerals in Brazil: *Econ Geology,* vol. **28,** no. 3, pp. 289–292, 1933.

ARGENTINA. Principal localities: The Sierra von Cordoba and other ranges in the provinces of Cordoba, San Luis, San Juan, Catamarca, and Salta, northwestern Argentina. Types: Mainly granite simple. Complex, with ore mineral (wolframite, molybdenite, and copper sulphide) phase in the Sierra von Cordoba. Tantalite and beryl occur in pegmatite near Quines, San Luis Province.

REFERENCES: Rodenbender, Wilhelm, Die Wolfram-Minen der Sierra von Cordoba in der Argentinischen Republik: *Zeit. für prakt. Geol.*, pp. 409–414, 1894. Kittl, Erwin, Tantalita de Quines (Tantalite from Quines): *Museo Nacional de Historia Natural,* (*Buenos Aires*), *Anales* **36,** pp. 335–342, 1931. Abstract *Annotated Bibliography of Econ. Geology,* vol. **5,** p. 1, no. 232.

CHILE. Pre-Cambrian crystalline rocks occur in a long narrow belt along the Chilean coast. Beryl has been reported from the Valparaiso district.

BOLIVIA. Principal locality: Metal mining province of western Bolivia. Type: Granite complex, with tin, tungsten, and lithium phases.

REFERENCES: Ahlfeld, F., Supergene cassiterite in tin veins: *Econ. Geology,* vol. **25,** pp. 546–548, Aug. 1930. Ahlfeld, F., Ueber die Verteilung des Wolframs in der bolivianischen Metallprovinz: *Chemie der Erde* (Linck u. Blauck), vol. **7**(1), pp. 121–129, 1932. Abstract in *Annotated Bibliography of Econ. Geology,* vol. **5**(2), no. 442.

PERU. Muscovite-bearing pegmatites occur in the vicinity of Arequipa, Southern Peru.

COLOMBIA. Localities: near Muzo, and in the southern part of the eastern cordillera. Types: Granite simple, and complex with beryllium (emerald) phase in Muzo district.

REFERENCES: Ball, S. H., The geologic and geographic distribution of precious stones: *Econ. Geology,* vol. **17,** pp. 575–602, 1922. Pogue, J. E., The emerald deposits of Muzo, Colombia: *Trans. Am. Inst. Min. Eng.*, vol. **55,** pp. 910–934, 1917. Vargas Vasquez, Luis, and Cuervo Araoz, Gabriel, Notes on mica deposits east of Garzon, Huila, Colombia: *Bol. Minas y Petr., Bogata,* vol. **4** (21–22), pp. 338–351, Sept. Oct., 1930. Abstract in *Annotated Bibliography of Econ. Geology,* vol. **4,** p. 1, no. 538.

(*To be continued*)