

Information Circular No. 4

IDAHO BUREAU OF MINES AND GEOLOGY

MOSCOW, IDAHO

AUGUST, 1959

Ignimbrite Bibliography

BY

E. F. COOK

State of Idaho

ROBERT E. SMYLIE, Governor

Idaho Bureau of Mines and Geology

E. F. COOK, Director

Information Circular No. 4

August, 1959

IGNIMBRITE BIBLIOGRAPHY

by

E. F. COOK

IDAHO BUREAU OF MINES AND GEOLOGY

MOSCOW, IDAHO

TABLE OF CONTENTS

	Page
Introduction	1
Historical outline	2
Limits of the bibliography	4
Acknowledgments	6
Listing by author	7
Geographic index	26
Subject index	29

IGNIMBRITE BIBLIOGRAPHY

by

E. F. Cook

INTRODUCTION

In recent years many rhyolitic and dacitic sheets, including some in Idaho, have come to be recognized as ignimbrites instead of the lava flows they were formerly thought to be. As their true nature is revealed, although their exact mode of origin remains in doubt, the great usefulness of ignimbrites in structural and stratigraphic studies has become apparent. For this reason they are the object of an increasing amount of research. To help the geologist who may be looking for references in this field, this bibliography has been prepared.

Ignimbrite as used here means "a nonsorted pyroclastic deposit of probable Pelean or nuee ardente origin." It is used as a rock unit and not as a rock type. An ignimbrite may be composed of tuff or tuff-breccia, and it may be welded, partially welded, or entirely nonwelded.

In addition to listing papers in which such rock units are described or mentioned, I have included in this bibliography references in which the possible mechanism of emplacement of ignimbrites is discussed. Any eruptive mechanism that involves a turbulent gas cloud and/or a gas-lubricated pyroclastic flow is considered a nuee ardente or glowing cloud.

I am aware that some students of these interesting rocks--especially some American students--do not accept ignimbrite and nuee ardente as useful terms. In light of the nomenclature controversy which exists, objectivity would require that this circular be titled, "Bibliography of Nonsorted Sheet-like Volcanic Rock Units, Some of Which Grade from Tuff into Lava-like Rock, and of the Eruptive Mechanisms by Which They May Have Formed."

To save the patience of other bibliographers, to avoid which-mires¹ in title and text, and because of personal preference, I have chosen to use ignimbrite and nuee ardente as defined above, though others may prefer the terms welded tuff and ash flow.

¹/For an illuminating discussion of this hazard see Thurber, J., 1931, Ladies' and Gentlemen's Guide to Modern English Usage, in the Owl in the Attic, Universal Library edition, p. 105.

HISTORICAL OUTLINE

Dr. Zirkel thought the pumice fragments in the Nevada rhyolite he was studying under his microscope were welded together. He said so (1876, p. 267), thus becoming the first geologist to use the word welded in the description of a rock type whose origin has become a subject of increasing interest and controversy since his pronouncement in Leipzig over 80 years ago. Strangely enough, the welded pumice fragments, the microlenticular structure, and the shivered crystal fragments that Zirkel so clearly described in the Nevada rhyolites collected during the Fortieth Parallel Survey seem to have aroused no suspicion in his mind that he might not be dealing with flow rocks, despite the fact that several years before he had noted both tuffaceous and flow features in some New Zealand rhyolites.^{2/}

It remained for J. P. Iddings (1899, p. 404), again using the word welded, in his descriptions of Yellowstone rhyolites, to formulate the first clear hypothesis^{3/} designed to explain the presence of both pyroclastic and liquid flow features in a single rock unit. This he did by supposing that a gas-charged lava flow under certain conditions might vesiculate so violently at and near its surface that it would form glass and pumice fragments which thereafter might be compressed while yet hot enough to fuse or weld together. In what appears at first glance to be a restatement of this hypothesis, ten years later (1909, p. 331), Iddings omitted the vesiculating flow idea, proposing merely that hot glass fragments may fall together and become welded into a mass that may then flow and harden into a firm rock. The change is perhaps significant in view of the great volume of literature which had appeared in the intervening decade on the nuee ardente eruptions of Mont Pele in Martinique.

The Pelean outbursts provided geologists with a possible explanation of the puzzling features of those volcanic rock units which seemed to grade from lava rock into tuff and which, locally or

^{2/}in Hochstetter, 1864, Reise der Frigate Novara. Geologie von Neu-Seeland, p. 111-116.

^{3/}Abich in 1882 had already put forward a froth-flow hypothesis for the Armenian tufflavas. Even earlier, von Fritsch and Reiss (1868, Geologische Beschreibung der Insel Tenerife, p. 420-422) had attempted to explain the eutaxitic structure and foreign fragments in some Canary Island rocks as the result of partial remelting of a tuff or agglomerate.

overall, shared the characteristics of both rock types.^{4/} Within a few years following the Martinique eruptions, rocks in Wales (Dakyns and Greenly, 1905), France (Boule, 1905; Glangeaud, 1918), Germany (Volzing, 1910), Japan (Yamasaki, 1911), and Italy (Zambonini, 1919) were interpreted as deposits of Pelean origin.

Many geologists remained unwilling to extrapolate the Pelean phenomena to cover the origin of large rhyolite and dacite sheets. After the interpretation in Pelean terms of the Katmaian "sand flow" by Fenner (1920, 1923), however, realization began to spread that puzzling features of the large acidic sheets might be explained by a nuee origin. In New Zealand the sheet rhyolites of North Island

^{4/}For interesting descriptions of rocks which were later interpreted as ignimbrites, see:

Abich, H., 1882, Geologische Forschungen in den Kaukasischen Landern, II. Geologie des Armenischen Hochlandes, I. Westhalbte: Vienna, A. Holder, 162 p.

Burbank, W. S., 1932, Geology and ore deposits of the Bonanza mining district, Colorado: U. S. Geol. Survey Prof. Paper 169, 166 p.

Diller, J. S., and Patton, H. B., 1902, The geology and petrography of Crater Lake National Park: U. S. Geol. Survey Prof. Paper 3, 167 p.

Fritsch, K. von, and Reiss, W., 1868, Geologische Beschreibung der Insel Tenerife: Winterthur, Verlag von Wurster, 494 p.

Park, J., 1887, On the Upper Wanganui and King Country: New Zealand Geol. Survey Rept. Geol. Explor. during 1886-87, no. 18, p. 167-182.

Park, J., and Rutley, F., 1899, Notes on the rhyolites of the Hauraki Goldfields (New Zealand): Geol. Soc. London Quart. Jour., v. 55, p. 441-469.

Ransome, F. L., Emmons, W. H., and Garrey, G. H., 1910, Geology and ore deposits of the Bullfrog district, Nevada: U. S. Geol. Survey Bull. 407, 130 p.

Rutley, F., 1900, Additional notes on some eruptive rocks from New Zealand: Geol. Soc. London Quart. Jour., v. 56, p. 493-510.

Sollas, W. J., and McKay, A., 1905, Rocks of the Cape Colville Peninsula, v. 1, 2: Wellington, Gov't. Printer.

Weyl, R., 1936, Stratigraphie und Tektonik der Grundgebirgsgrenze zwischen Kinzig und Elz in Mittleren Schwarzwald: Bad. Geol. Abh., v. 8, p. 46-126.

were named ignimbrites (glowing cloud rocks) by Marshall (1932, 1935) who assigned a Katmaian eruptive origin to them. Interestingly, Marshall was preceded in such an interpretation by Ferrar (1931), who had cited the Katmai parallel, and to some extent, by Henderson who, in 1913, had described a rock unit with flattened glass lenses in which the smaller fragments were fritted together, and as well by Morgan (1924), who had suggested that the peculiar features of this same rock type "are best explained by supposing that the individual fragments were all extremely hot, and semi-viscous, or in part quite viscous, when they fell."

The early (1905-1919) publications on rocks interpreted as Pelean deposits were all in foreign publications, most of them not readily available to American geologists. Belated stimulus for recognizing such deposits in the United States, as in New Zealand, was given mainly by Fenner's series of papers (published in the U. S., beginning in 1920) on the Katmaian "tuff-flow," but also by the arrival of Howel Williams at the University of California; Williams, fresh from work on the Snowdon volcanics of Wales, brought a new approach to the explanation of American pyroclastic deposits. From the University of California, in subsequent years, came one of the most comprehensive and informative papers on a Pelean deposit yet written (Gilbert, 1938), as well as the first stratigraphic use of a known ignimbrite to correlate widely separated rock series (Anderson and Russell, 1939).

Throughout the Western United States, the 1930's were the pioneer decade of ignimbrite study. C. S. Ross reported briefly on the ash-flow deposits of the Valles Mountains in New Mexico (1931); Moore (1934) recognized pumice-flow deposits near Crater Lake and published size-analysis histograms that illustrate the striking contrast in sorting between deposits of pumice flow and those of pumice fall (in the same year, Kozu distinguished between pumice-flow and pumice-fall deposits at Komagatake in Japan, and Richards and Bryan recognized the Brisbane tuff of Australia as an ignimbrite); Fuller described welded pumice in Oregon (1935); Mansfield and Ross found highly welded tuff extending over a considerable part of southeast Idaho (1935); and Fenner recognized welded tuff in the Yellowstone Park rhyolites (1936, 1937, 1938). In 1940 Lonsdale made the first published mention of welded tuff in west Texas.

Since the 1930's many papers have been written describing ancient Pelean deposits; they have been found in every continent except Antarctica, and are known to range in age from Precambrian to Recent.

LIMITS OF THE BIBLIOGRAPHY

With a few exceptions, only works in which deposits are considered to be of Pelean origin or in which the Pelean phenomena themselves are specifically mentioned have been included in this bibliography. By this criterion many articles of profound interest on deposits later interpreted as ignimbrites are excluded, whereas several of considerably less interest (but which contain mention of

such deposits) are included. Exceptions to the limit stated are: (a) the classic papers by Zirkei (1876), Iddings (1899, 1909), Henderson (1913), and Morgan (1924), in which welding or fritting of pyroclastic material is mentioned or clearly implied without the invocation of a Pelean origin; and (b) papers in which a nuee origin for rocks with ignimbrite characteristics is deliberately rejected in favor of some type of liquid-flow origin.

Descriptions of historic nées ardentes and discussion of this eruptive mechanism are included because observation of nées has greatly facilitated the interpretation of ignimbrites. Some students of the problem of ignimbrite origin, however, hold the nuee observations to be a misfortune instead of a boon, since the difference in origin of the sheet ignimbrites as compared to the deposits of observed nées may be one not only of degree but of kind. No one, for instance, has seen a nuee of anything like the size which would be required to produce an extensive ignimbrite. Furthermore, nearly all of the historic nées have issued from volcanoes and have left andesitic deposits whereas most of the sheet ignimbrites probably erupted from fissures and are in the rhyodacitic composition range. On the other hand, the published statement that no historic nuee has ever produced a welded deposit--used to support the argument that welded ignimbrites are of different origin from deposits of historic nées--is in error because the Agatsuma nuee deposit (formed at Asama in Japan in 1783) is in part welded (H. Kuno, personal communication).

Incidentally, the reader who seeks out the literature cited here will find what I call nées ardentes referred to not only as nées but as sand flows, tuff flows, ash flows, pyroclastic flows and glowing avalanches; and the resulting deposits are known variously as ignimbrites, welded tuffs, sillars, or by the name of the eruptive mechanism (tuff flow, ash flow, even nuee ardente).

This bibliography does not include theses, although some theses would certainly be of more value to the research worker in ignimbrites than are some of the papers listed.⁵

^{5/}Outstanding among theses on ignimbrites are the following:

Boyd, F. R., 1957, Geology of the Yellowstone rhyolite plateau: Harvard Univ. Ph.D. thesis, 134 p.

Martin, R. C., 1957, Vertical variations within some eastern Nevada ignimbrites: Univ. Idaho M.S. thesis, 86 p.

Sewell, C. R., 1955, Igneous petrology of Candelaria area, Presidio County, Texas: Univ. Texas M.A. thesis, 127 p.

Papers on volcanic mudflows (lahars and laodus);^{6/} volcanic breccias of vulcanian or of flow origin; airfall or waterlaid tuffs and tuff-breccias are not listed. I have also eliminated popular or semi-popular accounts of the Pelean eruptions and of the Valley of Ten Thousand Smokes and I have not included theoretical papers on the solubility of water in magmas, on the mechanics of ash formation, and the like, unless they contain specific references to nées or similar eruptive phenomena.

In summary, this bibliography includes all papers which have come to my attention on the rocks called ignimbrites, welded tuffs, or tufflavas, and on the mechanisms by which they are supposed to have been produced.

ACKNOWLEDGMENTS

For suggesting additions to this bibliography which my own efforts had not made known to me, I am indebted to the following: M. FAVORSKAYA, H. KUNO, J. WESTERVELD, J. T. LONSDALE, A. ISOTOFF, R. C. MARTIN, R. G. LUEDKE, W. H. NELSON, and H. WILLIAMS.

R. W. BURNS of the University of Idaho Library searched out and secured on loan for me many of the more obscure items not locally available.

The competent care and typing, through several revisions, of this bibliography and of the card file from which it sprang, by LENORE HANSON of the University of Idaho College of Mines staff, has made this publication possible.

^{6/} For information on volcanic mudflows, refer to the following good papers:

Anderson, C. A., 1933, The Tuscan formation of northern California, with a discussion concerning the origin of volcanic breccias: Univ. California Pub. Geol. Sci., v. 23, p. 215-276.

Curtis, G. C., 1903, Secondary phenomena of the West Indian volcanic eruptions of 1902: Jour. Geol., v. 11, p. 199-215.

Kemmerling, G. L. L., 1921, De uitbarsting van den G. Kloet in den nacht van den 19den op den 20sten mei 1919: Vulk. meded., No. 2, Dienst van het Mijnwezen in Nederlandsch Ost-Indie.

Neumann van Padang, M., 1933, De uitbarsting van den Merapi (midden Java) in de jaren 1930-31: Vulk. Seism. Meded., No. 12.

Schmidt, K. G., 1934, Die Schuttstrome am Merapi auf Java nach dem Ausbruch von 1930: De Ingenieur in Nederlandsch-Indie, IV. Mijnbouw en Geologie De Mijnbouw en Geologie (De Mijngenieur), v. 1, p. 91-120, 123-133, 134-172.

Scrivenor, J. B., 1929, The mudstreams ("Lahars") of Gunong Keloet in Java: Geol. Mag. (Great Britain), v. 66, p. 433-434.

LISTING BY AUTHOR

- Adamian, A. A., 1950, On the problem of stratigraphic subdivision of the tuff-tufflava sequence of the south slope of the Aragaz mountain massif (in Russian): Acad. Sci. Armenian S.S.R. Bull., Physico-mathematic, natural and technical sciences, v. 3, no. 2, p. 199-205.
- 1951, Tuffs and tufflavas of the south slope of the Aragaz mountain massif (in Russian): Acad. Sci. Armenian S.S.R. Bull., Physico-mathematic, natural and technical sciences, no. 3, p. 231-47.
- Ahrens, W., 1930, Geologisches Wanderbuch durch das Vulkangebiet des Laacher Sees in der Eifel: Stuttgart, Ferdinand Enke Verlag, 87 p.
- Afanasev, G. D., 1959, Specific properties of composition and the mechanism of penetration of the Cenozoic volcanic rocks of the Caucasus (abs.): Internat. Geology Review, v. 1, p. 86-87.
- Allen, V. T., and Nichols, R. L., 1945, Clay pellet conglomerates at Hobart Butte, Lane County, Oregon: Jour. Sed. Petrology, v. 15, p. 25-33.
- Amsbury, D. L., 1958, Geology of the Pinto Canyon area, Presidio County, Texas: Texas Bur. Econ. Geology Geol. Quad. Map No. 22.
- Amstutz, G. C., 1956, Some petrologic observations in the "rock forest" of Central Peru: Schweiz. Mineral. und Petrog. Mitt., v. 36, p. 63-68.
- Alcaraz, A., Abad, L. F., and Quema, J. C., 1952, Hibok-Hibok Volcano, Philippine Islands, and its activity since 1948: Part 1, Volcano Letter 516, p. 1-6; Part 2, Volcano Letter 517, p. 1-4.
- Anderson, A. L., 1956, Geology and mineral resources of the Salmon quadrangle, Lemhi County, Idaho: Idaho Bur. Mines and Geology Pamph. 106, 102 p.
- Anderson, C. A., 1933, The Tuscan formation of northern California, with a discussion concerning the origin of volcanic breccias: Univ. California Pub., Geol. Sci. Bull., v. 23, p. 215-276.
- 1941, Volcanoes of the Medicine Lake Highland, California: Univ. California Pub., Geol. Sci., v. 25, p. 347-422.
- Anderson, C. A., and Russell, R. D., 1939, Tertiary formations of northern Sacramento Valley, California: California Jour. Mines and Geology, v. 35, p. 219-253.

- Anderson, T., 1908, Report on the eruptions of the Soufriere in St. Vincent in 1902 and on a visit to Montagne Pelee in Martinique, Part II: Royal Soc. (London) Philos. Trans. A., v. 208, p. 275-302.
- Anderson, T., and Flett, J. S., 1902, Preliminary report on the recent eruption of the Soufriere in St. Vincent and of a visit to Mont Pelee in Martinique: Royal Soc. (London) Proc., v. 70; also in Nature, 1902, v. 66, p. 402-406, and Smithsonian Inst. Ann. Rept. for 1902, 1903, p. 309-330.
- 1903, Report on the eruption of the Soufriere in St. Vincent in 1902 and on a visit to Montagne Pelee in Martinique, Part I: Royal Soc. (London) Philos. Trans. A., v. 200, p. 353-553.
- Aramaki, S., 1956, The 1783 activity of Asama Volcano, Part I: Japanese Jour. Geology Geography Trans., v. 27, p. 189-229.
- 1957a, Classification of pyroclastic flows (in Japanese with English abs.): Volc. Soc. Japan Bull., ser. 2, v. 1, p. 47-51.
- 1957b, The 1783 activity of Asama Volcano, Part II: Japanese Jour. Geology Geography Trans., v. 28, p. 11-33.
- Aramaki, S., and Akimoto, S., 1957, Temperature estimation of pyroclastic deposits by natural remanent magnetism: Am. Jour. Sci., v. 255, p. 619-627.
- Ata, S., 1940, On the eruption of Sakurajima in October, 1939 (in Japanese): The Earthquake, v. 12, p. 60-65.
- Axelrod, D. I., 1956, Mio-Pliocene floras from west-central Nevada: Univ. California Pub. Geol. Sci., v. 33, p. 1-322.
- Barker, Fred, 1958, Precambrian and Tertiary geology of Las Tablas quadrangle, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 45, 104 p.
- Barksdale, J. D., 1949, Volcanic rocks in the Candelaria district, west-central Nevada (abs.): Geol. Soc. America Bull., v. 60, p. 1936.
- 1951, Cretaceous glassy welded tuffs--Lewis and Clark County, Montana: Am. Jour. Sci., v. 249, p. 439-443.
- Baumgart, I. L., and Healy, J., 1956, Recent vulcanicity at Taupo, New Zealand: Pacific Sci. Cong., 8th, Philippines, Proc., v. 2, p. 113-125.
- Beliankin, D. C., 1952, On the problem of the tuffaceous lavas of Armenia (in Russian): Acad. Sci. U.S.S.R. Bull., geol. ser., no. 3, p. 141-144.

- Bemmelen, R. W. van, 1949, The geology of Indonesia. General Geology: The Hague, Govt. Printing Office, v. 1A, 732 p.
- Bemmelen, R. W. van, and Rutten, M. G., 1955, Tablemountains of northern Iceland: Leiden, 217 p.
- Best, J. G., 1954, Investigations of recent volcanic activity in the Territory of New Guinea: Pacific Sci. Cong. Proc., no. 8, Philippines.
- Bordet, P., 1958, A propos des ignimbrites: Comptes Rendus Somm. Soc. Geol. de France, p. 77-80.
- Bouladon, J., and Jouravsky, G., 1954a, Sur la veritable nature de certaines laves de la serie volcanique du Precambrien III de Tiouine: Acad. sci. (Paris) Comptes rendus, t. 238, p. 599-601.
- 1954b, Les ignimbrites du Precambrien III de Tiouine et du Sud Marocain: Notes et Mem. Serv. geol. Maroc., no. 120, p. 37-58.
- Boule, M., 1905, La Montagne Pelee et les volcans d'Auvergne: La Geographie, Bull. de la soc. de Geogr., v. 11, p. 7-26.
- Bout, P., 1958, Considerations a propos des ignimbrites: Comptes Rendus Somm. Soc. Geol. de France, p. 189-191.
- Boyd, F. R., 1954, Volcanic history of a portion of the Yellowstone Park rhyolite plateau (abs.): Am. Geophys. Union Trans., v. 35, p. 377.
- Bryan, W. H., and Jones, O. A., 1954, Contributions to the geology of Brisbane. No. 2. The structural history of the Brisbane metamorphics: Royal Soc. (Queensland) Proc., v. 65, no. 2, p. 25-50.
- Burbank, W. S., 1941, Structural control of ore deposition in the Red Mountain, Sneffels, and Telluride districts of the San Juan Mountains, Colorado: Colorado Sci. Soc. Proc., v. 14, no. 5, p. 141-261.
- Callaghan, E., 1939, Volcanic sequence in the Marysvale region in southwestern central Utah: Am. Geophys. Union Trans., 20th annual meeting, p. 438-452.
- Campbell, I., Cone, J. E., Rogers, J. J. W., and Whitfield, J. M., 1958, Possible correlation of Rattlesnake and Danforth formations of eastern Oregon: Geol. Soc. America Bull., v. 69, p. 1678.
- Coats, R. R., 1957, Jarbridge quadrangle, Nevada, in geologic investigations of radioactive deposits--Semiannual progress report, Dec. 1, 1956, to May 31, 1957: U. S. Geol. Survey TEI-690, p. 303-312, issued by U. S. Atomic Energy Comm. Tech. Inf. Service, Oak Ridge, Tenn.

- Cole, G. N., 1918, Compressional heat in volcanic blasts: Monthly Weather Review, October, p. 453.
- Cook, E. F., 1955, Nomenclature and recognition of ignimbrites (abs.): Geol. Soc. America Bull., v. 66, p. 1544.
- _____, 1956, Volcanic stratigraphy (abs.): Resumenes de los Trabajos Presentados, Internat. Geol. Cong., 20th, Mexico, p. 7.
- _____, 1957, Geology of the Pine Valley Mountains, Utah: Utah Geol. and Mineralog. Survey Bull. 58, 111 p.
- _____, 1958, Stratigraphic study of eastern Nevada Tertiary volcanic rocks (abs.): Geol. Soc. America Bull., v. 69, p. 1548-49.
- Cotton, C. A., 1952, Volcanoes as landscape forms: Christchurch and London, Whitcombe and Tombs, 416 p.
- Crosby, I. B., 1940, Geology of the Virilla Canyon, Meseta Central Occidental, Costa Rica: Am. Sci. Cong. Proc., 8th, Washington, v. 4, p. 483-494.
- Curtis, G. H., 1955, Importance of Novarupta during eruption of Mt. Katmai, Alaska, in 1912 (abs.): Geol. Soc. America Bull., v. 66, p. 1547.
- Dakyns, J. R., and Greenly, E., 1905, On the probable Pelean origin of the felsitic slates of Snowdon, and their metamorphism: Geol. Mag., n.s., Decade 5, v. 2, p. 541-549.
- Day, A. L., and Allen, E. T., 1925, The volcanic activity and hot springs of Lassen Peak: Carnegie Inst. Washington Pub. 360, 190 p.
- DeFord, R. K., 1958, Tertiary formations of Rim Rock country, Presidio County, Trans-Pecos Texas: Texas Jour. Sci., v. 10, p. 1-37.
- Dianova, T. V., and Kuritsina, G. A., 1955, On the tufflavas of the Isovsk and Krasnouralsk districts (in Russian): Acad. Sci. U.S.S.R., Ural Branch, Min. geol. inst., Issue 26.
- Eifler, G. K., 1951, Geology of the Barrilla Mountains, Texas: Geol. Soc. America Bull., v. 62, p. 339-353.
- Elston, W. E., 1957, Geology and mineral resources of Dwyer quadrangle, Grant, Luna, and Sierra Counties, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 38, 86 p.
- Enlows, H. E., 1951, The igneous geology of Chiricahua National Monument, Arizona: Tulsa Geol. Soc. Digest, v. 19, p. 105-107.
- _____, 1955, Welded tuffs of the Chiricahua National Monument, Arizona: Geol. Soc. America Bull., v. 66, p. 1215-1246.

- Erickson, R. L., 1953, Stratigraphy and petrology of the Tascotal Mesa quadrangle, Texas: Geol. Soc. America Bull., v. 64, p. 1353-1386.
- Escher, B. G., 1931, Gloedwolken en lahar's. Vulkanische Katastrophen in Nederlandsch-Indie: Tropisch. Nederland, 3e Jaarg., no. 19, p. 291-304; and no. 20, p. 307-320.
- 1933a, On a classification of central eruptions according to gas pressure of the magma and viscosity of the lavas: Leid. Geol. Meded., Deel. VI, Afsl. I, p. 45-49.
- 1933b, On the character of the Merapi eruption in central Java: Leid. Geol. Meded., Deel. VI, Afsl. I., p. 50-58.
- Favorskaya, M. A., 1949, Tertiary tuff-lavas of southern Primorya (in Russian): Acad. Sci. U.S.S.R. Bull., geol. ser., v. 5, p. 137-141.
- 1956a, Upper Cretaceous and Cenozoic magmatism of the eastern slopes of Sikhote-Alinya (in Russian): U.S.S.R. Inst. Geol. Mineral Deposits Trans., fasc. 7, 306 p.
- 1956b, Upper Cretaceous and Kainozoic volcanism of Sikhote-Alin (abs.): Res. de los Trabajos Presentados, Int'l. Geol. Cong., 20th, Mexico, p. 8-9.
- 1957, On the problem of the mechanism of formation of some tufflavas (in Russian): Volcanological Laboratory Trans., Issue 14.
- Feitler, S., 1940, Welded tuff resembling vitrophyre and pitchstone at Bare Mountain, Nevada (abs.): Geol. Soc. America Bull., v. 51, p. 1957.
- Fenner, C. N., 1920, The Katmai region, Alaska, and the great eruption of 1912: Jour. Geology, v. 28, p. 569-606.
- 1923, The origin and mode of emplacement of the great tuff deposit in the Valley of Ten Thousand Smokes: Natl. Geogr. Soc. Contr. Tech. Papers, Katmai, no. 1, 74 p.
- 1925, Earth movements accompanying the Katmai eruption: Jour. Geology, v. 33, p. 116-139 and p. 193-223.
- 1934, The Annual Report of the Director of the Geophysical Laboratory for the Year 1933-34, Carnegie Inst. Washington Geophys. Lab. Paper 860, p. 63-67.
- 1936, Bore-hole investigations in Yellowstone Park: Jour. Geology, v. 44, p. 225-315.
- 1937, Tuffs and other volcanic deposits of Katmai and Yellowstone Park: Am. Geophys. Union Trans., 18th Annual Meeting, p. 236-289.

- Fenner, C. N., 1938, Contact relations between rhyolite and basalt on Gardiner River, Yellowstone Park: Geol. Soc. America Bull., v. 49, p. 1441-1484.
- 1948, Incandescent tuff-flows in southern Peru: Geol. Soc. America Bull., v. 59, p. 879-893.
- Ferrar, H. T., 1931, Te Kuiti subdivision: New Zealand Geol. Survey 25th Annual Report, no. 2, p. 3.
- Finch, R. H., 1935, On the mechanics of nées ardentes: Jour. Geology, v. 43, p. 545-550.
- Firman, R. J., 1957, The Borrowdale volcanic series between Wast-water and Duddon Valley, Cumberland: Yorkshire Geol. Soc. Proc., v. 31, pt. 1, p. 39-64.
- Fuller, M. L., 1935, Collapsed pumice (abs.): Geol. Soc. America Proc. for 1935, p. 329.
- Geze, B., 1957, Reflexions sur les ignimbrites et les laves acides: Comptes Rendus Somm. Soc. Geol. de France, p. 348-351.
- Geze, B., Hudeley, H., Vincent, P., and Wacrenier, Ph., 1957, Morphologie et dynamisme des grands volcans du Tibesti (Sahara du Tchad): Comptes Rendus Somm. Soc. Geol. de France, p. 117-120.
- Gilbert, C. M., 1938, Welded tuff in eastern California: Geol. Soc. America Bull., v. 49, p. 1829-1862.
- Gillerman, E., 1958, Geology of the central Peloncillo Mountains, Hidalgo County, New Mexico, and Cochise County, Arizona: New Mexico Bur. Mines and Mineral Resources Bull. 57, 152 p.
- Givens, D. B., 1957, Geology of Dog Springs quadrangle, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 58, 40 p.
- Glangeaud, P. H., 1918, Le volcan de Sancy. Ses volcans secondaires et ses laves: Acad. sci. (Paris) Comptes rendus, v. 167, p. 1076-1078.
- Gorshkov, G. S., 1959a, Kamchatka Valley of Ten Thousand Smokes: Volcanol. Soc. Japan Bull., ser. 2, v. 3, p. 154-156.
- 1959b, Giant eruptions of Volcano Bezymyannaya (abs.): Internat. Geology Review, v. 1, p. 82-83.
- Grange, L. I., 1934, Rhyolite sheet flows of the North Island of New Zealand: New Zealand Jour. Sci. and Technology, v. 16, no. 2, p. 57-67.
- 1937, Geology of the Rotorua-Taupo subdivision: New Zealand Geol. Survey Bull. 37.

- Guitard, G., 1956, Sur l'importance et la nature des manifestations volcaniques dans le paleozoïque inférieur des Pyrénées Orientales: Acad. sci. (Paris) Comptes rendus, t. 242, no. 23, p. 2749-2752.
- Harris, H. D., 1958, A late Mesozoic positive area in western Utah: Am. Assoc. Petroleum Geologists, 1958 Geol. Record, Rocky Mtn. Sec., Casper, Wyoming, p. 89-102.
- Hartmann, M., 1933, Bijdrage tot de kennis van gassen, sublimatie- en inkrustatieprodukten, en thermale wateren in de Merapi-ladoe's: Merapi volume, Vulk. Seism. Meded., no. 12, Dienst van den Mijnbouw in Nederlandsch-Indie.
- Hausen, D. M., 1954, Welded tuffs of Oregon and Idaho: Mississippi Acad. Sci. Jour. 1951-53, v. 5, p. 209-220.
- Henderson, J., 1913, The geology of the Te Aroha subdivision: New Zealand Geol. Survey Bull. 16 (esp. p. 70-72).
- Hewett, D. F., 1956, Geology and mineral resources of the Ivanpah quadrangle, California and Nevada: U. S. Geol. Survey Prof. Paper 275, 172 p.
- Hinds, N. E. A., 1935, Mesozoic and Cenozoic eruptive rocks of the southern Klamath Mountains, California: Univ. California Pub. Dept. Geol. Sci. Bull., v. 23, p. 313-380.
- Hjelmqvist, S., 1956, On the occurrence of ignimbrite in the Pre-Cambrian: Sveriges Geologiska Undersökning, ser. C, no. 542, Arsbook 49 (1955), 12 p.
- Houston, R. S., 1956, Preliminary report on the petrography of Tertiary volcanic rocks of the Jackson Hole area, Teton County, Wyoming; in Wyoming Geol. Assoc. Guidebook 11th Ann. Field Conf., Jackson Hole, Wyoming.
- Hovey, E. O., 1902a, St. Vincent and Martinique: a preliminary report upon the eruptions of 1902: Am. Museum Nat. Hist. Bull., v. 16, p. 333-372.
- 1902b, Observations on the eruptions of 1902 of La Soufrière, St. Vincent, and Mt. Pelee, Martinique: Am. Jour. Sci., v. 14, p. 319-358.
- 1904, The 1902-03 eruptions of Mont Pele, Martinique, and the Soufrière, St. Vincent: Internat. Geol. Cong., 9th, Vienna 1903, Comptes rendus, v. 10, p. 707-738.
- Iddings, J. P., 1899, Geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2 (esp. p. 404-406).
- 1909, Igneous Rocks, v. 1: New York, Wiley, 464 p.

- Ishikawa, T., and Minato, M., 1955, Age of the welded tuffs in northern Japan: *Actes du IV Congres de l'Assn. Intern. pour l'Etude du Quaternaire*, Rome, p. 1-8.
- Ishikawa, T., Minato, M., Kuno, H., Matsumoto, T., 1956, The welded tuffs in Japan (abs.): *Resumenes de los Trabajos Presentados, Internat. Geol. Cong.*, 20th, Mexico, p. 10.
- Jaggar, T. A., 1949, Steam blast volcanic eruptions: A study of Mount Pelee in Martinique as type volcano. *Fourth Special Report of the Hawaiian Volcano Observatory*: Honolulu, The Hawaiian Volcano Research Assoc., 137 p.
- Jenks, W. F., and Goldich, S. S., 1956, Rhyolitic tuff flows in southern Peru: *Jour. Geology*, v. 64, p. 156-172.
- Jicha, H. L., 1954, Geology and mineral deposits of Lake Valley quadrangle, Grant, Luna, and Sierra Counties, New Mexico: *New Mexico Bur. Mines and Mineral Resources Bull.* 37, 93 p.
- Johnson, M. S., and Hibbard, D. E., 1957, Geology of the Atomic Energy Commission Nevada Proving Grounds area, Nevada: *U. S. Geol. Survey Bull.* 1021-K, p. 333-384.
- Jones, O. A., and Jones, J. B., 1956, Notes on the geology of some North Queensland Islands. Parts I and II: *Reports of the Great Barrier Reef Committee*, v. 6, pt. 3, p. 31-54.
- Kamasaki, M., 1954, On the chemical composition of lavas of Nyoho-Akanagi Volcano, Nikko: *Tokyo Univ. Fac. Sci. Jour.*, sec. 2, v. 9, p. 2, p. 345-354.
- Katsui, Y., 1955, Geology and petrology of the volcano Mashu, Hokkaido, Japan (in Japanese with English abs.): *Geol. Soc. Japan Jour.*, v. 61, p. 481-495.
- Kelley, V. C., 1946, Geology, ore deposits, and mines of the Mineral Point, Poughkeepsie, and Upper Uncompahgre districts, Ouray, San Juan, and Hinsdale Counties, Colorado: *Colorado Sci. Soc. Proc.*, v. 14, no. 7, p. 289-466.
- Kemmerling, G. L. L., 1921, De hernieuwde werking van den vulkaan G. Merapi (midden Java) van begin Augustus 1920 tot en met Februari 1921: *Vulkanologische Mededeelingen* no. 3, Dienst van het Mijnwezen in nederlandsch-Oost-Indie.
- Kennedy, G. C., 1955, Some aspects of the role of water in rock melts: *Geol. Soc. America Special Paper* 62, p. 489-504.
- Kerr, P. F., et. al., 1952, Annual Report for July 1, 1951, to June 30, 1952. Part 1. A geologic guide to the Marysvale area: *U. S. Geol. Survey RMO-924*, 57 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service, Oak Ridge, Tennessee.

- Kerr, P. F., et al., 1957, Marysvale, Utah, uranium area: Geol. Soc. America Special Paper 64, 212 p.
- Kiepper, M. R., Weeks, R. A., and Ruppel, E. T., 1957, Geology of the southern Elkhorn Mountains, Jefferson and Broadwater Counties, Montana: U. S. Geol. Survey Prof. Paper 292, 82 p.
- Koto, B., 1916, The great eruption of Sakura-jima in 1914: Tokyo Imp. Univ. Coll. Sci. Jour., v. 38, art. 3, 237 p.
- Kozu, S., 1934, The great activity of Komagatake in 1929: Tschermak's Mineralogische und Petrographische Mitteilungen, v. 45, p. 133-174.
- Kuehlmer, F. J., 1954, Geologic section of the Black Range at Kingston, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 33, 100 p.
- Kuno, H., 1941, Characteristics of deposits formed by pumice flows and those by ejected pumice: Earthquake Research Inst. Bull., v. 19, p. 145-159.
- 1950, Geology of Hakone Volcano and adjacent areas, Part I: Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 7, p. 257-279.
- 1952, Cenozoic volcanic activity in Japan and surrounding areas: New York Acad. Sci. Trans., ser. 2, v. 14, p. 225-231.
- 1953, Formation of craters and magmatic evolution: Am. Geophys. Union Trans., v. 34, p. 267-280.
- Lacroix, A., 1902, Nouvelles observations sur les eruptions volcaniques de la Martinique: Acad. sci. (Paris) Comptes rendus, v. 135, p. 672-674 and p. 1301-1307.
- 1903a, Les eruptions de nuages denses de la Montagne Pelee: Acad. sci. (Paris) Comptes rendus, v. 136, p. 216-218.
- 1903b, L'eruption de la Montagne Pelee en janvier 1903: Acad. sci. (Paris) Comptes rendus, v. 136, p. 442-443.
- 1904, La Montagne Pelee et ses eruptions: Paris, Masson et Cie. 662 p.
- 1906a, Les conglomérats des explosions vulcaniennes de Vesuve: Acad. sci. (Paris) Comptes rendus, v. 142, p. 1020-1022.
- 1906b, Contribution a l'etude des breches et des conglomérats volcaniques (Antilles 1902-03, Vesuve 1906): Soc. geol. France Bull., v. 6, p. 635-685.
- 1908, La Montagne Pelee apres ses eruptions: Paris, Masson et Cie., 136 p.

Lacroix, A., 1930, Remarques sur les materiaux de projection des volcans et sur la genese des roches pyroclastiques qu'ils constituent: Livre Jubilaire du Centenaire Soc. geol. France, t. 2, p. 431-472.

Lacroix, A., Rollet de l'Isle and Giraud, 1902, Sur l'eruption de la Martinique: Acad. sci. (Paris) Comptes rendus, v. 135, p. 377-391 and 419-431.

Larsen, E. S., Jr., and Cross, W., 1956, Geology and petrology of the San Juan region, southwestern Colorado: U. S. Geol. Survey Prof. Paper 258, 303 p.

Lebedev, P. I., 1931, Zone of tuffaceous lava building stone at Alagez (Aragaz) (in Russian): Petrographic Institute Trans., Issue 1.

— 1947, On the problem of the nature of tuffaceous lava of the volcano Alagez (in Russian): Acad. Sci. U.S.S.R. Bull., geol. ser., no. 6, p. 119-120.

Lonsdale, J. T., 1940, Igneous rocks of the Terlingua-Solitario region, Texas: Geol. Soc. America Bull., v. 51, p. 1539-1626 (esp. p. 1563).

Love, J. D., 1956, Summary of geologic history of Teton County, Wyoming, during Late Cretaceous, Tertiary, and Quaternary times, in Wyoming Geol. Assoc. Guidebook 11th Ann. Field Conf., Jackson Hole, Wyoming.

Lovejoy, D. W., 1959, Overthrust Ordovician and the Nannie's Peak intrusive, Lone Mountain, Elko County, Nevada: Geol. Soc. America Bull., v. 70, p. 539-564.

MacDonald, G. A., and Alcaraz, A., 1956, Nuees ardentes of the 1948-1953 eruption of Hibok-Hibok: Bull. volcanol., Assoc. of Volcanology, I.U.G.G., ser. 2, v. 18, p. 169-178.

Macgregor, A. G., 1939, The volcanic history and petrology of Montserrat with observations on Mt. Pelee in Martinique: Royal Soc. (London) Philos. Trans., B, no. 557, v. 229, p. 1-90.

— 1946, Nuees ardentes and ignimbrites: Nature, v. 157, p. 305.

— 1952, Eruptive mechanisms: Mt. Pelee, the Soufriere of St. Vincent, and the Valley of Ten Thousand Smokes: Bull. volcanol., s. 2, t. 12, p. 49-74.

— 1955, Classification of Nuee Ardente eruptions in "X^e assemblée générale de l'Union Géodésique et Géophysique internationale à Rome": Bull. volcanol., s. 2, t. 16, p. 7-11.

Mackin, J. H., 1952, Hematite veinlets in an ignimbrite in the Iron Springs district, southwestern Utah (abs.): Geol. Soc. America Bull., v. 63, p. 1337-8.

- Mackin, J. H., Cook, E. F., and Threet, R. L., 1954, Stratigraphy of Early Tertiary volcanic rocks in southwestern Utah (abs.): Geol. Soc. America Bull., v. 65, p. 1280.
- Mackin, J. H., and Nelson, W. H., 1950, Early Tertiary welded tuffs in the Iron Springs district, southwestern Utah (abs.): Geol. Soc. America Bull., v. 61, p. 1528.
- Mansfield, G. R., and Ross, C. S., 1935, Welded rhyolitic tuffs in southeastern Idaho: Am. Geophys. Union Trans., 16th Ann. Meeting, p. 308-321.
- Marel, H. W. van der, 1941, Onderzoek omtrent het voorkomen van de mineralen orthiet en zirkoon in de liparietgronden van Sumatra's Oostkust: De Ingenieur in Nederlandsch-Indie, IV, Mijnbouw en Geologie (De Mijningenieur), VIII, no. 4, p. 33-38.
- Marshall, P., 1929, Building stones of New Zealand: New Zealand Dept. Sci. and Indust. Research Bull. 11, 45 p.
- 1932, Notes on some volcanic rocks of the North Island of New Zealand: New Zealand Jour. Sci. and Technology, v. 13, no. 4, p. 198-202.
- 1935, Acid rocks of the Taupo-Rotorua volcanic district: Royal Soc. (New Zealand) Trans., v. 64, p. 323-366.
- 1953, Ignimbrites: Pacific Sci. Cong., 7th, New Zealand 1949, Proc., v. 2, p. 407-411.
- Martin, R. C., 1959, Some field and petrographic features of New Zealand and American ignimbrites: New Zealand Jour. Geol. Geophys., v. 2, p. 394-411.
- Marwick, J., 1946, The geology of the Te Kuite subdivision: New Zealand Geol. Survey Bull. 41, 89 p.
- Matschinski, M., 1952, Sur les eruptions peleennes, pliniennes et hawaiennes: Soc. geol. France, Comptes rendus, no. 15-16, p. 341-346.
- Matsumoto, T., 1943, The four gigantic caldera volcanoes of Kyusyu: Japan Geol. Geog. Jour., v. 19, p. 1-57.
- Matsumoto, T., Ishikawa, T., and Minato, N., 1956, Some problems of welded lava and welded tuff related with the sunken calderas in Japan: Pacific Sci. Cong., 8th, Philippines, Proc., v. 2, p. 130-134.
- Maxwell, J. C., 1948, Geology of Tobago, British West Indies: Geol. Soc. America Bull., v. 59, p. 801-854.
- McAnulty, W. N., 1955, Geology of Cathedral Mountain quadrangle, Brewster County, Texas: Geol. Soc. America Bull., v. 66, p. 531-578.

- McKinlay, P. F., 1956, Geology of Costilla and Latir Peak quadrangles, Taos County, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 42, 32 p.
- 1957, Geology of Questa quadrangle, Taos County, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 53, 23 p.
- Mesropian, A. I., 1951, On the origin of the Quaternary Armenian tuffs (in Russian): Acad. Sci. Armenian S.S.R. Bull., v. 4, no. 4.
- Minato, M., and Hasegawa, Y., 1959, Studies of the welded tuffs in Japan--On the Neppu welded tuff (in Japanese with English abs.): Japan Geol. Soc. Jour., v. 65, p. 66-70.
- Minato, M., Ishii, J., and Kumano, S., 1959, A study of the welded tuffs in Japan--On the Shikotsu welded tuff (in Japanese with English abs.): Japan Geol. Soc. Jour., v. 65, p. 209-221.
- Mitchell, G. H., 1956, The Borrowdale volcanic series of the Dunnerdale Fells, Lancashire: Liverpool Manchester Geol. Jour., v. 1, p. 428-449.
- Moon, C. G., 1953, Geology of Agua Fria quadrangle, Brewster County, Texas: Geol. Soc. America Bull., v. 64, p. 151-196 (esp. p. 180)
- Moore, B. N., 1934, Deposits of possible nuee ardente origin in the Crater Lake region, Oregon: Jour. Geology, v. 42, p. 358-375.
- Morgan, P. G., 1924, The geology and mines of the Waihi district: New Zealand Geol. Survey Bull. 26., p. 65.
- Morris, H. T., 1957, General geology of the east Tintic Mountains, Utah: Utah Geol. Guidebook 12, p. 1-56.
- Neumann van Padang, M., 1933, De uitbarsting van den Merapi (midden Java) in de jaren 1930-1931: Vulk. Seism. Meded., no. 12.
- 1951, Catalogue of the active volcanoes of the world including solfatara fields, Part I, Indonesia: Ass. Volc. Union Geod. Geoph. Int., 271 p.
- Oftedahl, C., 1957, On ignimbrite and related rocks: No. 16 of studies on the igneous rock complex of the Oslo region, Skrifter Utgitt av Det Norske Videnskaps Akademi i Oslo. I. Mat.-Naturv. Klasse. No. 4.
- Oliver, R. L., 1954, Welded tuffs in the Borrowdale volcanic series, English Lake district, with a note on similar rocks in Wales: Geol. Mag. (Great Britain), v. 91, p. 473-483.
- Osborne, G. D., 1950, The Kutting vulcanicity of the Hunter-Karuah district, with specific reference to the occurrence of ignimbrites: Royal Soc. New South Wales Jour. and Proc., v. 83, p. 288-301.

- Paffengolts, K. N., 1938, On the problem of the age and genesis of Armenian tufflava (in Russian): All-Russian Mineralogical Society Mem., v. 67, no. 3, p. 526-541.
- Page, B. M., 1959, Geology of the Candelaria mining district, Mineral County, Nevada: Nevada Bur. Mines Bull. 56, 67 p. (esp. p. 30-36).
- Perret, F. A., 1924, The Vesuvius eruption of 1906: Carnegie Inst. Washington Pub. 339, 151 p. (esp. p. 90).
- 1935, The eruption of Mt. Pelee 1929-1932: Carnegie Inst. Washington Pub. 458, 125 p.
- 1940, Notes on the volcanism of the West Indies: Am. Sci. Cong., 8th, Washington Proc., v. 4, p. 751-756.
- 1950, Volcanological observations: Carnegie Inst. Washington Pub. 549, 162 p.
- Petrov, V. P., 1957, Ignimbrites and tufflavas. More on the nature of the Artik type (in Russian): Volcanological Laboratory Trans., Issue 14.
- Philemon, C., 1930, La Montagne Pelee: Paris, Impressions Printory, 211 p.
- Richards, H. C., and Bryan, W. H., 1934, The problem of the Brisbane tuff: Royal Soc. (Queensland) Proc., v. 45, p. 50-61.
- Rigby, J. K., 1958, Geology of the Stansbury Mountains: Utah Geol. Guidebook 13, p. 1-134.
- Rittmann, A., 1936, Vulkane und ihre Tätigkeit: Stuttgart, 188 p.
- 1944, Vulcani, attività e genesi: Napoli.
- 1951, Rilevamento geologico della Collina dei Camaldoli nei Campi Flegrei: Soc. geol. italiana Boll., v. 69, p. 129-177.
- Roberts, R. J., 1956, Flowage structure in central Nevada ignimbrites (abs.): Geol. Soc. America Bull., v. 67, p. 1780-81.
- Romer, M., 1936, La dernière éruption de la Montagne Pelee: Bull. volcanol., 8th yr., nos. 27 to 30, p. 89-116.
- Ross, C. P., 1953, The geology and ore deposits of the Reese River district, Lander County, Nevada: U. S. Geol. Survey Bull. 997, 132 p.
- Ross, C. S., 1931, The Valles Mountain volcanic center of New Mexico: Am. Geophys. Union Trans., p. 185-186.

- Ross, C. S., 1953, Characteristics of rhyolite welded tuffs in western North America: Pacific Sci. Cong., 7th, New Zealand, Proc., v. 2, p. 407.
- 1955, Provenience of pyroclastic materials: Geol. Soc. America Bull., v. 66, p. 427-434.
- 1958, Welded tuff from deep-well cores from Clinch County, Georgia: Am. Mineralogist, v. 43, p. 537-545.
- Rybalov, B. L., 1957, On the origin of some tufflava of a south-western spur of the northern Tien Shan (in Russian): Volcano-logical Laboratory Trans., Issue 14.
- Sabins, F. F., 1957, Geology of the Cochise Head and western part of the Vanar quadrangles, Arizona: Geol. Soc. America Bull., v. 68, p. 1315-1342.
- Saito, M. and Osanai, K., 1952, On the Noboribetsu welded tuff: Geol. Committee Hokkaido, No. 20.
- Sapper, K., 1905, In den Vulkangebieten Mittelamerikas und West-indiens: Stuttgart, 334 p.
- Sapper, K., and Termer, F., 1930, Der Ausbruch des Vulkans Santa Maria in Guatemala vom 2-4 Nov. 1929: Zeit. fur Vulkanologie, v. 13, p. 73-101.
- Shelton, J. S., 1955, Glendora volcanic rocks, Los Angeles Basin, California: Geol. Soc. America Bull., v. 66, p. 45-90.
- Shepard, E. S., and Merwin, H. E., 1927, Gases of the Mont Pele lavas of 1902: Jour. Geology, v. 35, no. 2, p. 97-116.
- Shirinian, K. G., 1956, The stratigraphic subdivision of the Quaternary tuff-tufflava assemblage of the Aragaz area (in Russian): in Problems of the geology and hydrogeology of Armenia, Erevan, p. 74-82.
- 1957, New data on the eruption centers of the tuffs and tuff-lavas in Armenia (in Russian): Contrib. Acad. Sci. Armenian S.S.R., v. 24, no. 2.
- 1958, On the structure and origin of the tuff-tufflava assemblage in Armenia (in Russian): Acad. Sci. Armenian S.S.R. Proc., geol. ser., v. K-1, no. 1.
- 1959, General features of recent volcanism in Armenia (abs.): Internat. Geology Review, v. 1, p. 85-86.
- Shirinian, K. G., and Aslanian, A. T., 1956, The perfect columnar jointing of the volcanic tuff-blankets of Armenia in relation to their origin (in Russian): Trans. Erevan Polytech. Inst., geol. mining ser., no. 3.

- Smirnov, G. M., and Arevadzye, V. L., 1941, Tuffs and tuffaceous lava of the Teletsk Range (in Russian): Gruzinsk State Geologic Board Trans., Issue 5, p. 229-238.
- Smith, R. L., Friedman, I., and Long, W. D., 1958, Welded tuffs, experimental I (abs.): Amer. Geophys. Union Trans., v. 39, p. 532-533.
- Smith, W. C., Segerstrom, K., and Guiza, R., 1950, Tin deposits of Durango, Mexico: U. S. Geol. Survey Bull. 962-D, p. 155-204.
- Solovev, S. P., 1950, The principal features of the complex of young acid effusives and ignimbrites in southern Sikhote-alin, and its petrochemical characteristics (in Russian): All-Russian Mineral. Soc. Mem., v. 79, p. 211-222.
- Staatz, M. H., 1957, Thomas Range, Utah: Geol. Inv. Rad. Deps., Semiannual progress report for Dec. 1, 1956, to May 31, 1957, U. S. Geol. Survey TEI-690, p. 298-302, issued by U. S. Atomic Energy Comm. Tech. Inf. Service, Oak Ridge, Tennessee.
- Staples, L. W., 1950, The welded-tuff problem: Geol. Soc. Oregon Country Geol. News Letter, v. 16, no. 1, p. 2-6.
- Stearns, H. T., Bryan, L. L., and Crandall, L., 1939, Geology and water resources of the Mud Lake region, Idaho: U. S. Geol. Survey Water-Supply Paper 818, 125 p.
- Stearns, H. T., Crandall, L., and Steward, W. G., 1938, Geology and ground-water resources of the Snake River Plain in south-eastern Idaho: U. S. Geol. Survey Water-Supply Paper 774, 268 p.
- Stearns, H. T., and Isotoff, A., 1956, Stratigraphic sequence in the Eagle Rock volcanic area near American Falls, Idaho: Geol. Soc. America Bull., v. 67, p. 19-34.
- Stehn, C. E., 1936, Beobachtungen an Glutwolken während der erhöhten Tätigkeit des Vulkans Merapi in Mittel-Java in den Jahren 1933-1935: Handel. v/h 7 de Ned.-Indie. Natuurwet Congres, Batavia, p. 647-656.
- Steiner, A., 1958, Petrogenetic implications of the 1954 Ngaurohoe lava and its xenoliths: New Zealand Geol. Geophys. Jour., v. 1, p. 325-363.
- Stepanov, V. Y., 1935, Microscopic description of Adjarian tuff-lava (in Russian): S. O. P. R. Trans., Transcaucasus ser., Issue 14 M-L.
- Sun, M.-S., and Baldwin, B., 1958, Volcanic rocks of the Cienega area, Santa Fe County, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 54, 80 p.

- Taneda, S., 1954, Geological and petrological studies on the "Shirasu" in south Kyushu, Japan, Part I. Prelim. note: Kyushu Univ. Fac. Sci. Mem. s. D, v. 4, no. 2, p. 167-177.
- Taylor, G. A., 1956a, An outline of Mount Lamington eruption phenomena: Pacific Sci. Cong., 8th, Philippines, Proc., v. 2, p. 83-88.
- 1956b, Review of volcanic activity in the territory of Papua--New Guinea, the Solomon and New Hebrides Islands, 1951-53: Bull. volcanol., s. 2, t. 18, p. 25-37.
- Thompson, B. N., 1958, The geology of the Atiamuri dam site: New Zealand Geol. Geophys. Jour., v. 1, p. 275-306.
- Thompson, G. A., 1956, Geology of the Virginia City quadrangle, Nevada: U. S. Geol. Survey Bull. 1042-C, p. 45-75.
- Thomson, J. E., and Williams, 1956, The myth of the Sudbury lopolith (abs.): Resumenes de los Trabajos Presentados, Internat. Geol. Cong., 20th, Mexico, p. 300.
- Tonking, W. H., 1957, Geology of Puertecito quadrangle, Socorro County, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 41, 67 p.
- Tsuya, H., and Minakami, T., 1940, Minor activity of Volcano Sakurazima in October, 1939 (in Japanese): Earthquake Research Inst. Bull., v. 18, p. 318-339.
- Van Houten, F. B., 1956, Reconnaissance of Cenozoic sedimentary rocks of Nevada: Am. Assoc. Petroleum Geologists Bull., v. 40, p. 2801-2825.
- Vlodavets, V. I., 1953, On some Semyachkinsk tufflava and its origin (in Russian): Acad. Sci. U.S.S.R. Bull., geol. ser., no. 3.
- 1955, Alcuni risultati delle ricerche vulcanologiche nell'URSS: Bull. volcanol., s. 2, v. 16, p. 147-158.
- 1957, On the origin of the rock usually called tufflava and ignimbrite (in Russian): Volcanological Laboratory Trans., Issue 14.
- Volovikova, I. M., 1957, Ignimbrites of the Kuraminsk area (northern Tien Shan) (in Russian): Volcanological Laboratory Trans., Issue 14.
- Volzing, K., 1910, Der Trass des Brohltales: Jb. Konigl. Preuss. Geol. Landesanst., v. 28 (1907).
- Weecksteen, G., 1957, Sur la presence d'ignimbrites dans le Cameroun occidental: Acad. sci. (Paris) Comptes rendus, v. 244, p. 911-913.

- Westerveld, J., 1943, Welded rhyolitic tuffs or "ignimbrites" in the Pasoemah region, West Palembang, South Sumatra: Leidsche Geol. Mededeelingen Decl. 23, Afl. 1, p. 202-217.
- 1947, On the origin of the acid volcanic rocks around Lake Toba, North Sumatra: Verhand. Konink. Nederl. Akad. Wetenschappen, Afd. Natuur. Fed. Sect., v. 48, no. 1, p. 3-51.
- 1952, Quaternary volcanism on Sumatra: Geol. Soc. America, Bull., v. 63, p. 561-594.
- 1953, Eruptions of acid pumice tuffs and related phenomena along the great Sumatra fault trough system: Pacific Sci. Cong., 7th, New Zealand, Proc., v. 2, p. 411-438.
- 1956, Phases of Neogene and Quaternary volcanism in Asia Minor (abs.): Resumenes de los Trabajos Presentados, Internat. Geol. Cong., 20th Mexico, p. 21-22.
- Weyl, R., 1954, Die Smelztuffe der Balsamkette (Beitrage zur Geologie El Salvador): Neues Jb. Geol. u. Palaont., Abh. 99, 1, p. 1-31.
- 1957, Vulkanismus und Plutonismus im sudlichen Mittelamerika: Geol. Rundschau, v. 46, p. 220-228.
- Wilcox, R. E., 1944, Rhyolite-basalt complex on Gardiner River, Yellowstone Park, Wyoming: Geol. Soc. America Bull., v. 55, p. 1047-1080.
- Wilkinson, W. D., 1950, Welded tuff member of the Rattlesnake formation (abs.): Geol. Soc. America Bull., v. 61, p. 1534.
- Willard, M. E., 1957, Reconnaissance geologic map of Luera Spring quadrangle: New Mexico Bur. Mines and Mineral Resources Geol. Map 3.
- Willard, M. E., and Givens, D. B., 1958, Reconnaissance geologic map of Datil thirty-minute quadrangle: New Mexico Bur. Mines and Mineral Resources Geol. Map 5.
- Williams, H., 1926, Notes on the characters and classification of pyroclastic rocks: Liverpool Geol. Soc., 67th, Proc., Part 3, v. 14, p. 223-248.
- 1928, The geology of Snowdon (North Wales): Geol. Soc. London Quart. Jour., v. 83, p. 346-431.
- 1929, Geology of the Marysville Buttes, California: Univ. Calif. Pub. Geol. Sci., v. 18, p. 103-220.
- 1932, Geology of the Lassen Volcanic National Park, California: Univ. Calif. Pub. Dept. Geol. Sci. Bull., v. 21, p. 195-385.

- Williams, H., 1941a, Calderas and their origin: Univ. California Pub. Geol. Sci. Bull., v. 25, p. 239-346.
- _____, 1941b, Volcanology: Geol. Soc. America, 50th Ann. Vol., p. 365-390.
- _____, 1942, The geology of Crater Lake National Park, Oregon: Carnegie Inst. Washington Pub. 540, 157 p.
- _____, 1952a, The great eruption of Coseguina, Nicaragua, in 1835: Univ. Calif. Pub. Geol. Sci., v. 29, p. 21-46.
- _____, 1952b, Volcanic history of the Meseta Central occidental, Costa Rica: Univ. California Pub. Geol. Sci. 29, p. 145-180.
- _____, 1953, The ancient volcanoes of Oregon: Oregon System Higher Educ., 2nd ed., 55 p.
- _____, 1954, Problems and progress in volcanology: Geol. Soc. London Quart., v. 109, p. 311-322.
- _____, 1957, Glowing avalanche deposits of the Sudbury basin: Ontario Dept. of Mines, 65th Ann. Rep., p. 57-89.
- Williams, H., and Meyer-Abich, H., 1953, El origen del Lago de Ilopango: Comunicaciones Inst. Trop. Invest. Cient., v. 2, no. 1.
- _____, 1955, Volcanism in the southern part of El Salvador: Univ. California Dept. Geol. Sci. Bull., v. 32, p. 1-64.
- Williams, H., Turner, F. J., and Gilbert, C. M., 1954, Petrography: San Francisco, W. H. Freeman, 406 p.
- Yamaguchi, K., 1937-38, Petrological study of "ash-stones" around the northern part of Kagoshima Bay (in Japanese): Geol. Soc. Japan Jour., v. 44, p. 745-773; v. 45, p. 227-236; 277-286; 329-341; 537-551.
- Yamasaki, N., 1911, The condition of the eruption of Mt. Asama in 1783 (in Japanese): Rep. Earthquake Inv. Comm., no. 73, p. 20-28.
- _____, 1959, Role of water in volcanic eruption (in Japanese with English abs.): Bull. Volc. Soc. Japan, ser. 2, v. 3, p. 95-106.
- Zalessky, B. V. and Petrov, V. P., 1931, Artik deposits of tuffaceous lava (in Russian): Petrographic Institute Trans., Issue 1.
- Zambonini, F., 1919, Il tufo pipernoide della Campania e i suoi minerali: Mem. par. serv. alla descrizione della Carta geologica d'Italia, v. 7, pt. 2, 130 p.

- Zavaritsky, A. N., 1946a, On the Quaternary volcanic tuffs of Armenia: Acad. Sci. U.S.S.R. Reports, v. 53, no. 8, p. 729-731.
- ____ 1946b, On some volcanological data in connection with studies of Quaternary Armenian tuffs and tufflavas (in Russian): Acad. Sci. Armenian S.S.R. Bull., no. 10.
- ____ 1947, Ignimbrites of Armenia: Acad. Sci. U.S.S.R. Bull., geol. ser., 1947-no. 3, p. 1-18.
- ____ 1948, In connection with the remarks of P. I. Lebedev on the nature of tuffaceous lava of Armenia (in Russian): Acad. Sci. U.S.S.R. Bull., geol. ser., no. 3, p. 125-126.
- Zeller, R. A., Jr., 1959a, Reconnaissance geologic map of Playas quadrangle: New Mexico Bur. Mines and Mineral Resources Geol. Map 7.
- ____ 1959b, Reconnaissance geologic map of Dog Mountains quadrangle: New Mexico Bur. Mines and Mineral Resources Map 8.
- Zirkel, F., 1876, United States Geological Exploration of the 40th Parallel, v. VI, Microscopical Petrography (esp. p. 5, p. 267).

Mau, H., 1959, "Ignimbritos" na regiao de Cacapava do Sul, Rio Grande do Sul (in Portuguese with English abstract): Engenharia, Mineracao, e Metalurgia, v. 29, p. 13-14.

Oftedahl, C., 1958, A theory of exhalative-sedimentary ores: Sartryck ur geol. foren. i Stockholm forh., vol. 80, No. 1, p. 1-19.

GEOGRAPHIC INDEX

AFRICA---

- Cameroon: Weecksteen 1957.
Chad: Geze, Hudeley, Vincent, Wacrenier 1957.
Morocco: Bouladon, Jouravsky 1954a, 1954b.

ASIA---

- China: Kuno 1952.
Indonesia: Bemmelen 1949; Escher 1931, 1933b; Hartmann 1933; Kemmerling 1921; Marei 1941; Neumann van Padang 1933; Stehn 1936; Westerveld 1943, 1947, 1952, 1953.
Japan: Aramaki 1956, 1957; Ata 1940; Ishikawa, Minato 1955; Ishikawa, Minato, Kuno, Matsumoto 1956; Kamasaki 1954; Katsui 1955; Koto 1916; Kozu 1934; Kuno 1941, 1950, 1952, 1953; Matsumoto 1949; Matsumoto, Ishikawa, Minato 1956; Minato, Hasegawa 1959; Minato, Ishii, Kumano 1959; Saito, Osanai 1952; Taneda 1954; Tsuya, Minakami 1940; Williams 1951a; Yamaguchi 1937-38; Yamasaki 1911.
New Guinea: Best 1954; Taylor 1956a, 1956b.
Philippines: Alcaraz, Abad, Quema 1952; MacDonald, Alcaraz 1956.
Turkey: Westerveld 1956.
USSR: Dianova, Kuritsina 1955; Favorskaya 1949, 1956a, 1956b; Gorshkov 1959a, 1959b; Rybalov 1957; Solovev 1950; Vlodavets 1953; Volovikova 1957.

AUSTRALIA---

- Bryan, Jones 1954; Jones, Jones 1956; Osborne 1950; Richards, Bryan 1934.

CENTRAL AMERICA---

- Costa Rica: Crosby 1940; Williams 1952b.
El Salvador: Weyl 1954; Williams, Meyer-Abich 1953, 1955.
Guatemala: Sapper, Termer 1930.
Nicaragua: Weyl 1957; Williams 1952a.

EUROPE---

England: Firman 1957; Mitchell 1956; Oliver 1954.

France: Boule 1905; Glangeaud 1918; Guitard 1956; Lacroix 1906a; Rittmann 1944.

Germany: Ahrens 1930; Volzing 1910.

Hungary: Ross, C. S., 1955.

Italy: Hjelmqvist 1956; Rittmann 1951; Zambonini 1919.

Norway: Oftedahl 1957.

Sweden: Hjelmqvist 1956.

USSR: Adamian 1950, 1951; Afanasev 1959; Beliankin 1952; Lebedev 1931, 1947; Mesropian 1951; Paffengolts 1938; Petrov 1957; Shirinian 1956, 1957, 1958, 1959; Smirnov, Arevadzye 1941; Stepanov 1935; Zalessky, Petrov 1931; Zavaritsky 1946a, 1946b, 1947, 1948.

Wales: Dakyns, Greenly 1905; Oliver 1954; Williams 1928.

ICELAND---

Bemmelen, Rutten 1955.

NEW ZEALAND---

Baumgart, Healy 1956; Ferrar 1931; Grange 1934, 1937; Henderson 1913; Marshall 1929, 1932, 1935, 1953; Martin 1959; Marwick 1946; Morgan 1924; Steiner 1958; Thompson, B. N., 1958.

NORTH AMERICA---

Ross, C. S., 1953.

Alaska:

Curtis 1955; Fenner 1920, 1923, 1925, 1934, 1937.

Arizona:

Enlows 1951, 1955; Sabins 1957.

California:

Anderson, C. A., 1933, 1941; Anderson, Russell 1939; Day, Allen 1925; Gilbert 1938; Hewett 1956; Hinds 1935; Shelton 1955; Williams 1929, 1932.

Canada:

Thomson, Williams 1956; Williams 1957.

Colorado:

Burbank 1941; Kelley 1946; Larsen, Cross 1956.

Florida:

Ross, C. S., 1958.

Georgia:

Ross, C. S., 1958.

Idaho:

Anderson, A. L., 1956; Hausen 1954; Mansfield, Ross 1935; Stearns, Bryan, Crandall 1939; Stearns, Crandall, Steward 1938; Stearns, Isotoff 1956.

- Mexico: Smith, Segerstrom, Guiza 1950.
- Montana: Barksdale 1951; Klepper, Weeks, Ruppel 1957.
- Nevada: Axelrod 1956; Barksdale 1949; Coats 1957; Cook 1958; Feitler 1940; Hewett 1956; Johnson, Hibbard 1957; Lovejoy 1959; Page 1959; Roberts 1956; Ross, C. P., 1953; Thompson, G. A., 1956; Van Houten 1956; Zirkel 1876.
- New Mexico: Barker 1958; Eiston 1957; Gillerman 1958; Givens 1957; Jicha 1954; Kuehlmer 1954; McKinlay 1956, 1957; Ross, C. S., 1931; Sun, Baldwin 1958; Tonking 1957; Wargo 1959; Willard 1957; Willard, Givens 1958; Zeller 1959a, 1959b.
- Oregon: Allen, Nichols 1945; Campbell, Cone, Rogers, Whitfield 1958; Fuller 1935; Hausen 1954; Moore 1934; Wilkinson 1950; Williams 1942, 1953.
- Texas: Amsbury 1958; DeFord 1958; Eifler 1951; Erickson 1953; Lonsdale 1940; McAnulty 1955; Moon 1953.
- Utah: Callaghan 1939; Cook 1957; Harris 1958; Kerr et al 1952, 1957; Mackin, Nelson 1950; Mackin, Cook, Threet 1954; Morris 1957; Rigby 1958; Staatz 1957.
- Wyoming: Boyd 1954; Fenner 1936, 1937, 1938; Houston 1956; Iddings 1899; Kennedy 1955; Love 1956; Wilcox 1944.

SOUTH AMERICA---

- Brazil: Mau 1959.
- Peru: Amstutz 1956; Fenner 1948; Jenks, Goldich 1956.

WEST INDIES---

Anderson, T., 1908; Anderson, Flett 1902, 1903; Barrabe 1955; Hovey 1902a, 1902b, 1903, 1904; Jaggar 1949; Lacroix 1902, 1903, 1904, 1906, 1908, 1930; Lacroix, Rollet de l'Isle, Giraud 1902; MacGregor 1939; Maxwell 1938; Perret 1935; Philemon 1930; Romer 1936; Sapper 1905; Shepard, Merwin 1927.

SUBJECT INDEX

HISTORIC PELEAN ERUPTIONS---

- Japan: Aramaki 1956, 1957b; Ata 1940; Koto 1916; Kozu 1934; Tsuya, Minakami 1940.
- Katmai: Curtis 1955; Fenner 1920, 1923.
- Lassen: Day, Allen 1925; Williams 1932.
- Merapi: Escher 1933b; Hartmann 1933; Kemmerling 1921; Neumann van Padang 1933, 1951; Stehn 1936.
- Pele: Anderson, T., 1908; Anderson, Flett 1902, 1903; Hovey 1902a, 1902b, 1904; Jaggar 1949; Lacroix 1902, 1903a, 1903b, 1904, 1908, 1930; Perret 1935; Philemon 1930; Romer 1936; Sapper 1905.
- Papua-New Guinea area: Best 1954; Taylor 1956a, 1956b.
- Hibok-Hibok, Philippines: Alcaraz, Abad, Quema 1952; MacDonald, Alcaraz 1956.
- Santa Maria, Guatemala: Sapper, Termer 1930.

IGNIMBRITES---

- Andesitic: Anderson, C. A., 1941; Aramaki 1957b; Crosby 1940; Ishikawa, Minato, Kuno, Matsumoto 1956; Klepper, Weeks, Ruppel 1957; Kuno 1950; Maxwell 1948; Shelton 1955; Williams 1952b.
- Basaltic: Bemmelen, Rutten 1955; Lovejoy 1959.
- Internal structure: Gilbert 1938; Martin 1959; Roberts 1956; Shirinian, Aslanian 1956.
- Liquid-flow hypothesis of origin: Favorskaya 1956a, 1957; Grange 1934, 1937; Hausen 1954; Iddings 1899; Kennedy 1955; Vlodavets 1957.
- Stratigraphic use of: Adamian 1950; Anderson, Russell 1939; Callaghan 1939; Campbell, Cone, Rogers, Whitfield 1958; Cook 1956, 1957, 1958; Gillerman 1958; Harris 1958; Mackin, Cook, Threet 1954; Shirinian 1956.

NUEES ARDENTES---

Classification:

Aramaki 1957a, 1957b; Escher 1933a, 1933b; Lacroix 1904, 1930; MacGregor 1952, 1955; Rittmann 1944.

Mechanism:

Anderson, T., 1908; Anderson, Flett 1903; Boyd 1957; Cole 1918; Escher 1931; Fenner 1920, 1923, 1948; Finch 1935; Givens 1957; Hartmann 1933; Henderson 1913; Hovey 1902a, 1902b, 1904; Jaggar 1949; Lacroix 1902, 1903a, 1903b, 1904, 1906b, 1908, 1930; MacGregor 1946, 1952; Marshall 1932, 1935; Matschinski 1952; Perret 1924, 1935, 1940, 1950; Shepard, Merwin 1927; Williams 1941b, 1953, 1954; Williams, Turner, Gilbert 1954.

Nomenclature

of deposits:

Cook 1955; Cotton 1952; Fenner 1948; Jenks, Goldich 1956; Marshall 1932, 1935; Marwick 1946; Staples 1950; Weyl 1954.

PRE-CENOZOIC IGNIMBRITES---

Cretaceous: Barksdale 1951; Klepper, Weeks, Ruppel 1957.

Triassic: Bryan, Jones 1954; Richards, Bryan 1934.

Permian: Oftedahl 1957.

Carboniferous: Osborne 1950.

Late

Paleozoic(?): Jones, Jones 1956.

Early

Paleozoic(?): Mau 1959; Ross, C. S., 1958.

Ordovician: Dakyns, Greenly 1905; Firman 1957; Mitchell 1956; Oliver 1954; Williams 1928.

Cambrian(?): Guitard 1956.

Precambrian: Bouladon, Jouravsky 1954a, 1954b; Hjelmqvist 1956; Thomson, Williams 1956; Williams 1957.

RECOGNITION OF NONWELDED IGNIMBRITES---

Aramaki, Akimoto 1957; Cook 1955; Kuno 1941; Lacroix 1908, 1930; Moore 1934; Williams 1926.