Terrestrial Impact Structures— A Bibliography

GEOLOGICAL SURVEY BULLETIN 1220

Terrestrial Impact Structures— A Bibliography

By JACQUELYN H. FREEBERG

GEOLOGICAL SURVEY BULLETIN 1220

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1966

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. GS 66-245

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 70 cents (paper cover)

CONTENTS

ILLUSTRATION

TERRESTRIAL IMPACT STRUCTURES—A BIBLIOGRAPHY

By JACQUELYN H. FREEBERG

ABSTRACT

This bibliography lists 110 features for which origin by meteoritic impact has been suggested and gives a comprehensive group of references for each feature. Annotations for the more significant contributions to the literature are included. The structures are divided into six categories, and their geographic locations are indicated on a sketch map.

INTRODUCTION

The compilation of a bibliography on terrestrial impact structures was prompted by an increasing interest in meteoritic impact as a factor in the geologic process and by the analogy of these structures to similar features on the moon. The bibliography is comprehensive in order to serve as wide a range of public interest as possible. Something of an attempt to evaluate the entries has been made by reviewing as many of the articles as possible and by including in the bibliography annotations for some of the more significant contributions to the literature of each structure.

The first section of the bibliography lists the references on distribution and general characteristics of impact structures in order to provide information on a large number of structures; these papers are noted in the lists for specific structures by a "see also" reference. Otherwise, any set of citations for a particular structure is intended to constitute a complete bibliography of that structure. Cutoff date on entries included is December 1964.

Most structures for which an impact origin has been suggested in the literature are included and are alphabetically listed in the contents. Names by which features are known naturally vary; alternate names appear in the text and also in an index. Locations of the structures are shown on the accompanying sketch map (pl. 1). The geographical coordinates for each structure are given under its listing in the bibliography.

As search for undiscovered craters and research on the geology of those presently known continues, the list can be expected to change, perhaps rapidly.

CLASSIFICATION OF STRUCTURES

Currently, only 11 of the 110 features listed here are universally accepted as meteorite craters. Some indication of the nature of, and reason for including, the others seems useful. A classification using six categories adapted from Shoemaker and Eggleton,[1] with a list of structures belonging to each group, follows. The category to which each structure is assigned is also noted in the bibliography.

Category 1: Craters, or clusters of craters, with associated meteorites.

- Barringer Crater, Ariz.
- Boxhole Crater, Australia
- Campo del Cielo Craters, Argentina
- Dalgaranga Crater, Australia
- Haviland Crater, Kans.
- Henbury Craters, Australia
- Kaalijärv Craters, Estonia
- Odessa Craters, Tex.
- Sikhote-Alin Craters, U.S.S.R.
- Wabar Craters, Saudi Arabia
- Wolf Creek Crater, Australia

Category 2: Craters with form and structure of meteorite craters and associated phases probably of shock origin.

- Aouelloul Crater, Mauritania
- Clearwater Lakes, Canada
- Holleford Crater, Canada
- Lake Bosumtwi, Ghana
- Richât Crater, Mauritania
- Rieskessel, Germany

Category 3: Craters with the form and structure of meteorite craters.

- Lonar Lake, India
- New Quebec Crater, Canada
- Pretoria Salt Pan, South Africa
- Steinheim Basin, Germany
- Talemzane Crater, Algeria

Category 4: Deeply eroded or buried structures possibly of impact origin.

- Brent Crater, Canada
- Crooked Creek structure, Mo.
- Decaturville disturbance, Mo.
- Flynn Creek structure, Tenn.
- Glasford structure, Ill.
- Howell structure, Tenn.
- Jeptha Knob structure, Ky.
- Kentland structure, Ind.
- Kilmichael structure, Miss.
- Manicouagan-Mushalagan Lakes area, Canada
- Manson structure, Iowa
- Middlesboro Basin, Ky.

[1] Shoemaker, E. M., and Eggleton, R. E., 1961, Terrestrial features of impact origin, *in* Proceedings of the Geophysical Laboratory/Lawrence Radiation Laboratory Cratering Symposium, Washington, D.C., March 28–29, 1961: California Univ., Livermore, Lawrence Radiation Lab. Rept. UCRL–6438, pt. 1, paper A, 27 p. (Report prepared for U.S. Atomic Energy Commission.)

Serpent Mound structure, Ohio
Sierra Madera structure, Tex.
Versailles structure, Ky.
Vredefort structure, South Africa
Wells Creek area (main structure), Tenn.

Category 5: Features probably of nonimpact origin.

Al Umchaimin Crater, Iraq
Arnhem Land Crater, Australia
Carolina Bays, U.S.
Crater Elegante, Mexico
Crestone Crater, Colo.
Duckwater Crater, Nev.
Eyre Peninsula Craters, Australia
Franktown Crater, Canada
Gwarkuh Crater, Iran
Hungarian Plain, Hungary-Romania
Malha Crater, Sudan
Mount Doreen Crater field, Australia
Panamint Crater, Calif.
Semsiyât dome, Mauritania
Socotra Crater, Socotra
Tiffin Crater, Iowa
Tunguska event, U.S.S.R.
Upheaval Dome, Utah

Category 6: Structures for which more data are required for classification.

Amak Island Crater, Alaska
Amguid Crater, Algeria
Baghdad Craters, Iraq
Basra Crater, Iraq
Carswell Lake structure, Canada
Chinge site, U.S.S.R.
Deep Bay, Canada
Des Plaines disturbance, Ill.
Dycus disturbance, Tenn.
Dzioua Craters, Algeria
Ellef Ringnes Island Craters, Canada
Glover Bluff structure, Wis.
Gulf of St. Lawrence arc, Canada
Hagens Fjord Craters, Greenland
Hérault Craters, France
Ilumetsa Craters, Estonia
Ka-imu-hoku, Hawaii
Kalkkop structure, South Africa
Keeley Lake, Canada
Köfels site, Austria
Lac Couture, Canada
Lake Dellen, Sweden
Lake El'gytkhyn, U.S.S.R.
Lake Humeln, Sweden
Lake Michikamau, Canada
Lake Mien, Sweden
Lake Siljan, Sweden

Macamic Lake, Canada
Mecatina Crater, Canada
Melville Island Craters, Canada
Menihek Lake area, Canada
Merewether Crater, Canada
Merriwell Lake, Canada
Morasko Craters, Poland
Murgab Craters, U.S.S.R.
Nastapoka Islands arc, Canada
Nebiewale Crater, Ghana
New Mexico Crater, N. Mex.
Paris (Sucy-en-Brie and Alentours) lakes, France
Parry Sound Crater, Canada
Patomskii Crater, U.S.S.R.
Pilot Lake, Canada
Sault au Cochons structure, Canada
Sayan Crater, U.S.S.R.
Sudbury Basin, Canada
Temimichât-Ghallaman Crater, Mauritania
Tenoumer Crater, Mauritania
Tvären Bay, Sweden
Ungava Bay, Canada
Wells Creek area (three craters), Tenn.
West Hawk Lake, Canada
Wilbarger dome, Tex.
Wilkes Land structure, Antarctica
Winkler Crater, Kans.

SERIALS

The following list gives abbreviated titles of serials cited in this bibliography, with complete titles as used in library catalogs and union lists of serials and place of publication. The issuing agency, if not a commercial publisher, is included.

Acad. Nat. Sci. Philadelphia Proc.—Academy of Natural Sciences of Philadelphia, Proceedings. Philadelphia, Pa.

Acad. Sci. [Paris] Comptes Rendus—Comptes Rendus de l'Académie des Sciences. Paris, France.

Acta Geog.—Acta Geographica. Geografiska sallskapet i Finland. Helsinki, Finland.

Akad. Nauk Eston. SSR Inst. Geologii Trudy—Akademiya Nauk Estonskoy SSR, Institut Geologii, Trudy. Tallinn, Estonia.

Akad. Nauk Kazakh. SSR Vestnik—Akademiya Nauk Kazakhskoy SSR, Vestnik. Alma Ata, Kazakhskoy SSR.

Akad. Nauk SSSR Comptes Rendus, Doklady—
Akad. Nauk SSSR Doklady—
Akad. Nauk SSSR Izv. ser. geog. i geofiz.—
Akad. Nauk SSSR Vestnik—
Akademiya Nauk SSSR, Comptes Rendus, Doklady *and* Doklady *and* Izvestiya, seriya geograficheskaya i geofizicheskaya *and* Vestnik. Moscow, U.S.S.R.

Akad. Nauk SSSR Doklady, Earth Sci. Sec.—Akademiya Nauk SSSR, Doklady, Earth Science Section [translated]. American Geological Institute. Washington, D.C.

Akad. Nauk SSSR, Lomonosovskogo Inst. Geokhimii, Kristallografii i Mineralogii, Trudy—Akademiya Nauk SSSR, Lomonosovskogo Institut Geokhimii, Kristallografii i Mineralogii, Trudy. Leningrad, U.S.S.R.

Akad. Nauk SSSR, Sibirskoe Otdelenie, Inst. Geologii i Geofiziki, Trudy—Akademiya Nauk SSSR, Sibirskoe Otdelenie, Institut Geologii i Geofiziki, Trudy. Novosibirsk, U.S.S.R.

Akad. Nauk Tadzik. SSR Doklady—Akademiya Nauk Tadzhikskoy SSR, Doklady. Stalinabad, Tadzhik SSR.

Akad. Wiss. Berlin, Phys.-math. Kl., Abh.—Akademie der Wissenschaften in Berlin, Physikalische-mathematisch Klasse, Abhandlungen.

Akad. Wiss. München Sitzungsber.—Akademie der Wissenschaften in München. Sitzungsberichte. Munich, Germany.

Akad. Wiss. Wien, Math.-naturw. Kl., Anz.—

Akad. Wiss. Wien, Math.-naturw. Kl., Sitzungsber.—

Akademie der Wissenschaften in Wien, Mathematisch-naturwissenschaftliche Klasse, Anzeiger *and* Sitzungsberichte. Vienna, Austria.

Am. Acad. Arts Sci. Proc.—American Academy of Arts and Sciences, Proceedings. Boston, Mass.

Am. Assoc. Adv. Sci. Proc.—American Association for the Advancement of Science, Proceedings. Washington, D.C.

Am. Assoc. Petroleum Geologists Bull.—American Association of Petroleum Geologists, Bulletin. Tulsa, Okla.

Am. Astron. Soc. Pub.—American Astronomical Society, Publications. Ann Arbor, Mich.

Am. Geologist—American Geologist. Minneapolis, Minn.

Am. Geophys. Union Trans.—American Geophysical Union, Transactions. Washington, D.C.

Am. Inst. Mining Metall. Petroleum Engineers Trans.—American Institute of Mining, Metallurgical, and Petroleum Engineers, Transactions. New York, N.Y.

Am. Jour. Sci.—American Journal of Science. New Haven, Conn.

Am. Mineralogist—American Mineralogist. Mineralogical Society of America. Washington, D.C.

Am. Philos. Soc. Proc.—

Am. Philos. Soc. Yearbook—

American Philosophical Society, Proceedings *and* Yearbook. Philadelphia, Pa.

Am. Scientist—American Scientist. Society of the Sigma Xi. New Haven, Conn.

Annales Géographie—Annales Géographie. Bulletin de la Société de Géographie. Paris, France.

Arctic—Arctic. Arctic Institute of North America. Ottawa, Canada.

Argentina Dir. Minas Geol. Pub.—Argentina, Dirección de Minas y Geología, Publicación. Buenos Aires, Argentina.

Arizona Highways—Arizona Highways. Phoenix, Ariz.

Arizona Mining Jour.—Arizona Mining Journal. Phoenix, Ariz.

Assoc. Am. Geographers Annals—Association of American Geographers, Annals. Washington, D.C.

Aster [Barcelona]—Aster. Barcelona, Spain.

Astron. Jour.—Astronomical Journal. American Astronomical Society. New York, N.Y.

Astron. Kalendar' Gorkiy—Astronomicheskiy Kalendar'. Gorkiy, U.S.S.R.

Astron. Soc. Pacific Pub.—Astronomical Society of the Pacific, Publications. San Francisco, Calif.

Astron. Tsirk.—Astronomicheskiy Tsirkuliar. Akademiya Nauk SSSR. Moscow, U.S.S.R.

Astron. Zhur.—Astronomicheskiy Zhurnal. Akademiya Nauk SSSR. Moscow, U.S.S.R.

Astronomie—Astronomie et Bulletin de la Société Astronomique de France. Paris, France.

Australia, Aerial, Geol. and Geophys. Survey of Northern Australia, Rept., Northern Territory—Australia, Aerial, Geological and Geophysical Survey of Northern Australia, Report, Northern Territory. Canberra, Australia.

Australian and New Zealand Assoc. Adv. Sci. Rept.—Australian and New Zealand Association for the Advancement of Science, Report. Sydney, Australia.

Australian Jour. Sci.—Australian Journal of Science. Sydney, Australia.

Austria Geol. Bund. Verh.—Austria, Geologische Bundesanstalt, Verhandlungen. Vienna, Austria.

Bavaria Oberbergamt Geol. Land. Abh.—Bavaria, Oberbergamt, Geologische Landesuntersuchung, Abhandlungen. Munich, Germany.

Bayerische Akad. Wiss. Sitzungsber.—Bayerische Akademie der Wissenschaften, Sitzungsberichte. Munich, Germany.

Bayerische Staatssamml. Paläont. Hist. Geol. Mitt.—Bayerische Staatssammlung für Paläontologie und Historische Geologie, Mitteilungen. Munich, Germany.

Beitr. Geophysik—Beiträge zur Geophysik (also Gerlands Beiträge zur Geophysik). Leipzig, Germany.

British Astron. Assoc. Jour.—British Astronomical Association, Journal. Middlesex, England.

British Interplanetary Soc. Jour.—British Interplanetary Society, Journal. London, England.

California Univ., Livermore, Lawrence Radiation Lab. Rept.—University of California, Livermore, Lawrence Radiation Laboratory, Report. Livermore, Calif.

Canada Geol. Survey Bull.—
Canada Geol. Survey Map—
Canada Geol. Survey Paper—
Geological Survey of Canada, Bulletin *and* Map *and* Paper. Ottawa, Canada.

Canadian Mineralogist—Canadian Mineralogist. Mineralogical Association of Canada. Ottawa, Canada.

Canadian Field-Naturalist—Canadian Field-Naturalist. Ottawa Field-Naturalists' Club. Ottawa, Canada.

Časopsis—Časopsis Československých ústavů astronomických. Prague, Czechoslovakia.

Chemie der Erde—Chemie der Erde. Jena, Germany.

Colorado Mus. Nat. History Proc.—Colorado Museum of Natural History, Proceedings. Denver, Colo.

Compressed Air Mag.—Compressed Air Magazine. Easton, Pa.

Copenhagen Univ. Mus. Mineralogie et Geologie Commun. Geol.—Copenhagen University, Muséum de Minéralogie et de Géologie, Communications Géologiques. Copenhagen, Denmark.

Current Sci.—Current Science. Indian Institute of Science. Bangalore, India.
Dansk Geol. Foren. Meddel.—Dansk Geologisk Forening, Meddelelser. Copenhagen, Denmark.
Desert Mag.—Desert Magazine. Palm Desert, Calif.
Deutsche Geol. Gesell. Zeitschr.—Deutsche Geologische Gesellschaft, Zeitschrift. Hannover, Germany.
Earth Sci.—Earth Science. Chicago, Ill.
Earth Sci. Digest—Earth Science Digest (*also* Earth Science). Chicago, Ill.
Eclogae Geol. Helvetiae—Eclogae Geologicae Helvetiae. Societé Geologique Suisse. Basel, Switzerland.
Elisha Mitchell Sci. Soc. Jour.—Elisha Mitchell Scientific Society, Journal. Chapel Hill, N.C.
Eng. Mining Jour.—Engineering and Mining Journal. Chicago, Ill.
Eng. Mining Jour.-Press—Engineering and Mining Journal-Press. New York, N.Y.
Explorers Jour.—Explorers Journal. Explorers Club. New York, N.Y.
Field and Laboratory—Field and Laboratory. Dallas, Tex.
Forschung. und Fortschr.—Forschungen und Fortschritte. Berlin, Germany.
Fortschr. Mineralogie—Fortschritte der Mineralogie, Kristallographie und Petrographie. Deutsche Mineralogische Gesellschaft. Berlin, Germany.
France Centre Natl. Recherche Sci. Colloques Internat.—France, Centre National de la Recherche Scientifique, Colloques Internationaux. Paris, France.
French West Africa Dir. Mines Bull.—French West Africa, Direction Féderale des Mines et de la Geologie, Bulletin. Dakar, French West Africa.
Geochemistry [English translation]—Geochemistry [English translation]. Geochemical Society, Washington, D.C.
Geochim. et Cosmochim. Acta—Geochimica et Cosmochimica Acta. London, England.
Geog. Jour. [London]—Geographical Journal. Royal Geographical Society. London, England.
Geog. Wochenschr.—Geographische Wochenschrift. Frankfurt, Germany.
Geokhimiya—Geokhimiya. Akademiya Nauk, Moscow, U.S.S.R.
Geol. Assoc. Canada Proc.—Geological Association of Canada, Proceedings. Toronto, Canada.
Geologists' Assoc. London Proc.—Geologists' Association, London, Proceedings. London, England.
Geol. Bavarica—Geologica Bavarica. Bayerisches Geologisches Landesamt. Munich, Germany.
Geol. Fören. Stockholm Förh.—Geologiska Föreningen i Stockholm, Förhandlingar. Stockholm, Sweden.
Geol. Gesell. Wien Mitt.—Geologische Gesellschaft in Wien, Mitteilungen. Vienna, Austria.
Geol. Jahrb.—Geologisches Jahrbuch. Geologischen Landesanstalten der Bundesrepublik Deutschland. Hannover, Germany.
Geol. Mag. [London]—Geological Magazine. Hertford, England.
Geol. Rundschau—Geologische Rundschau. Stuttgart, Germany.
Geol. Soc. America Bull.—
Geol. Soc. America Guidebook for field trips—
Geol. Soc. America Proc.—
Geol. Soc. America Spec. Paper—
Geological Society of America, Bulletin *and* Guidebook for field trips *and* Proceedings *and* Special Paper. New York, N.Y.

Geol. Soc. London Quart. Jour.—Geological Society of London, Quarterly Journal. London, England.

Geol. Soc. South Africa Proc.—

Geol. Soc. South Africa Trans.—

Geol. Soc. South Africa Trans. and Proc.—

Geological Society of South Africa, Proceedings *and* Transactions *and* Transactions and Proceedings. Johannesburg, South Africa.

Geologie und Bauwesen—Geologie und Bauwesen. Vienna, Austria.

Geophysics—Geophysics. Society of Exploration Geophysicists. Tulsa, Okla.

Georgia Geol. Survey Bull.—Georgia, Geological Survey, Bulletin. Atlanta, Ga.

Gerlands Beitr. Geophysik—Gerlands Beiträge Geophysik. Leipzig, Germany.

Ghana Jour. Sci.—Ghana Journal of Science. Accra, Ghana.

Gold Coast Geol. Survey Bull.—

Gold Coast Geol. Survey Rept.—

Gold Coast, Geological Survey, Bulletin *and* Report. Accra, Gold Coast.

Griffith Observer—Griffith Observer. Griffith Observatory. Los Angeles, Calif.

Harvard Univ., Peabody Mus. Am. Archeology and Ethnology Papers—Harvard University, Peabody Museum of American Archeology and Ethnology, Papers. Cambridge, Mass.

Illinois Water Survey Coop. Ground-Water Rept.—Illinois, State Water Survey, Cooperative Ground-Water Report. Urbana, Ill.

Ingenieur—De Ingenieur. Paris, France.

India Geol. Survey Records—India, Geological Survey, Records. Calcutta, India.

Indian Minerals—Indian Minerals. India, Geological Survey. Calcutta, India.

Inst. Français Afrique Noire Bull.—Inst. Français d'Afrique Noire, Bulletin. Paris, France.

Internat. Geology Rev.—International Geology Review. American Geological Institute. Washington, D.C.

Iowa Acad. Sci. Proc.—Iowa Academy of Science, Proceedings. Des Moines, Iowa.

Irish Astron. Jour.—Irish Astronomical Journal. Armagh, Northern Ireland.

Jour. Astronaut. Sci.—Journal of the Astronautical Sciences. American Astronautical Society. New York, N.Y.

Jour. Atmospheric and Terrestrial Physics, Spec. Supp.—Journal of Atmospheric and Terrestrial Physics, Special Supplement. New York, N.Y.

Jour. Geology—Journal of Geology. Chicago, Ill.

Jour. Geophys. Research—Journal of Geophysical Research. American Geophysical Union. Washington, D.C.

Kansas Acad. Sci. Trans.—Kansas Academy of Science, Transactions. Lawrence, Kans.

Kentucky Geol. Survey, ser. 6—Kentucky Geological Survey, series 6. Lexington, Ky.

Kommunist [Yerevan]—Kommunist. Yerevan, U.S.S.R.

Kosmos [Stuttgart]—Kosmos. Stuttgart, Germany.

Kumamoto Jour. Sci.—Kumamoto Journal of Science. Kumamoto, Japan.

Liverpool Geol. Soc. Proc.—Liverpool Geological Society, Proceedings. Liverpool, England.

Meteoor—De Meteoor. Utrecht, The Netherlands.

Meteorbeobachter—Der Meteorbeobachter. Meteorbeobachtungsgruppe München. Munich, Germany.

Meteorit. Soc. Contr.—Meteoritical Society, Contributions. Los Angeles, Calif.

Meteoritics—Meteoritics. Meteoritical Society. New Haven, Conn.

Meteoritika—Meteoritika. Akademiya Nauk SSSR. Moscow, U.S.S.R.

Mineralog. Mag. [London]—Mineralogical Magazine. Mineralogical Society. London, England.

Mineralogist—Mineralogist. Menstone, Calif.

Mines Mag.—Mines Magazine. Golden, Colo.

Mining Eng.—Mining Engineering. American Institute of Mining, Metallurgical, and Petroleum Engineers. New York, N.Y.

Mining Jour. [Phoenix]—Mining Journal. Phoenix, Ariz.

Mining Rev.—Mining Review. Salt Lake City, Utah.

Mining Sci. Press—Mining and Scientific Press. San Francisco, Calif.

Mississippi Acad. Sci. Proc.—Mississippi Academy of Science, Proceedings. State College, Miss.

Mississippi Geol. Survey Bull.—Mississippi Geological Survey, Bulletin. University, Miss.

Missouri Geol. Survey and Water Resources [Rept.]—Missouri Geological Survey and Water Resources, [Report]. Rolla, Mo.

Mus. Northern Arizona Mus. Notes—Museum of Northern Arizona, Museum Notes. Flagstaff, Ariz.

Natl. Acad. Sci. Proc.—National Academy of Sciences, Proceedings. Washington, D.C.

Natl. Acad. Sci.-Natl. Research Council Pub., Nuclear Sci. Ser. Rept.—National Academy of Sciences-National Research Council, Publication, Nuclear Science Series, Report. Washington, D.C.

Natl. Geog. Mag.—National Geographic Magazine. National Geographic Society. Washington, D.C.

Nat. History—Natural History. American Museum of Natural History. New York, N.Y.

Natur und Volk—Natur und Volk. Senckenbergische Naturforschende Gesellschaft. Frankfurt, Germany.

Nature—London, England.

Nature [Paris]—La Nature. Paris, France.

Naturen—Naturen. Bergens Museum. Bergen, Norway.

Naturwiss. Ver. Schwaben und Neuberg (e.v.) Augsburg Abh.—Naturwissenschaftlicher Verein für Schwaben und Neuberg (e.v.), Augsburg, Abhandlungen. Augsburg, Germany.

Naturwiss. Wochenschr.—Naturwissenschaftliche Wochenschrift. Deutsches Gesellschaft für Volkstümliche Naturkunde in Berlin. Berlin, Germany.

Naturwissenschaften—Die Naturwissenschaften. Gesellschaft Deutsches Naturforscher und Arzte, und die Max-Planck-Gesellschaft zur Forderung der Wissenschaften. Berlin, Germany.

Nederlandse Akad. Wetensch. Verh.—Nederlandse Akademie van Wetenschappen. Verhandelingen. Amsterdam, The Netherlands.

Neues Jahrb. Mineralogie Geognosie Geologie und Petrefaktenk.—Neues Jahrbuch fur Mineralogie, Geognosie, Geologie und Petrefaktenkunde. Stuttgart, Germany.

Neues Jahrb. Mineralogie Geologie und Paläontologie, Beilage-Band—
Neues Jahrb. Mineralogie Geologie und Paläontologie, Monatsh.—
Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band *and* Monatshefte. Stuttgart, Germany.

New Mexico Univ. Pub. Meteoritics—University of New Mexico Publications in Meteoritics. Albuquerque, N. Mex.

New York Acad. Sci. Trans.—New York Academy of Sciences, Transactions. New York, N.Y.

Nordisk Astron. Tidsskr.—Nordisk Astronomisk Tidsskrift. Copenhagen, Denmark.

Oberrheinischer Geol. Ver. Jahresber. und Mitt.—Oberrheinischer Geologischer Verein, Jahresberichte und Mitteilungen. Stuttgart, Germany.

Observatory—Observatory, Royal Greenwich Observatory. Hailsham, England.

Ontario Dept. Mines Ann. Rept.—Ontario, Department of Mines, Annual Report, Ottawa, Canada.

Ottawa Dominion Observatory Contr.—

Ottawa Dominion Observatory Pub.—

Ottawa, Dominion Observatory, Contributions *and* Publications. Ottawa, Canada.

Pacific Discovery—Pacific Discovery. California Academy of Sciences. Berkeley, Calif.

Pan-Am. Geologist—Pan-American Geologist. Des Moines, Iowa.

Pennsylvania State Univ., Mineral Industries—Pennsylvania State University, Mineral Industries. State College, Pa.

Petermanns Geog. Mitt.—Petermanns Geographische Mitteilungen. Gotha, Germany.

Petermanns Mitt.—Petermanns Mitteilungen (also Petermanns Geographische Mitteilungen). Gotha, Germany.

Polar Times—Polar Times. American Polar Society. Rego Park, N.Y.

Pop. Astronomy—Popular Astronomy. Goodsell Observatory, Northfield, Minn.

Preuss. Geol. Landesanstalt und Bergakad. Sitzungsber.—Preussische Geologische Landesanstalt und Bergakademie, Sitzungsberichte. Berlin, Germany.

Priroda—Priroda. Moscow, U.S.S.R.

Priroda [Brno]—Priroda. Brno, Czechoslovakia.

Problems of the North—Problems of the North [translation of Problemy Severa]. National Research Council. Ottawa, Canada.

Problemy Severa—Problemy Severa. Akademiya Nauk SSSR. Moscow, U.S.S.R.

Quebec Dept. Nat. Resources Prelim. Rept.—Quebec, Department of Natural Resources, Preliminary Report. Quebec, Canada.

Rev. Géog. Lyon—Revue de Géographie de Lyon. Lyon, France.

Rocks and Minerals—Rocks and Minerals. Peekskill, N.Y.

Royal Astron. Soc. Canada Jour.—Royal Astronomical Society of Canada, Journal. Toronto, Canada.

Royal Central Asian Soc. Jour.—Royal Central Asian Society, Journal. London, England.

Royal Geog. Soc. Australasia, South Australian Branch, Proc.—Royal Geographical Society of Australasia, South Australian Branch, Proceedings. Adelaide, Australia.

Royal Meteorol. Soc. Quart. Jour.—Royal Meteorological Society, Quarterly Journal. London, England.

Royal Soc. Canada Minutes Proc.—

Royal Soc. Canada Trans.—

Royal Society of Canada, Minutes and Proceedings *and* Transactions. Ottawa, Canada.

Royal Soc. London Philos. Trans.—Royal Society of London, Philosophical Transactions. London, England.

Royal Soc. South Australia Trans. and Proc.—Royal Society of South Australia, Transactions and Proceedings. Adelaide, Australia.

Schwaben—Schwaben. Gesellschaft der Freunde des Würtembergischen Landesamts für Denkmalpflege. Stuttgart, Germany.

Science—Science. American Association for the Advancement of Science. Washington, D.C.

Sci. Am.—Scientific American. New York, N.Y.

Sci. Monthly—Scientific Monthly. Washington, D.C.

Sky and Telescope—Sky and Telescope. Cambridge, Mass.

Smithsonian Contr. Astrophysics—Smithsonian Contributions to Astrophysics. Smithsonian Institution. Washington, D.C.

Smithsonian Inst. Ann. Rept.—Smithsonian Institution, Annual Report. Washington, D.C.

Smithsonian Misc. Colln.—Smithsonian Miscellaneous Collections. Smithsonian Institution. Washington, D.C.

Soc. Research on Meteorites Contr.—Society for Research on Meteorites, Contributions. Los Angeles, Calif.

South Africa Dept. Mines Expl. of Sheet—South Africa, Department of Mines, Explanation of Sheet. Pretoria, South Africa.

South Africa Geol. Survey Mem.—South Africa, Geological Survey, Memoir. Pretoria, South Africa.

South Australian Mus. Rec.—South Australian Museum, Records. Adelaide, Australia.

South Carolina Acad. Sci. Bull.—South Carolina Academy of Science, Bulletin. Columbia, S.C.

Soviet Astron.-AJ—Soviet Astronomy-AJ [a translation of Astronomischeskiy Zhurnal]. American Institute of Physics. New York, N.Y.

Soviet-bloc Research in Geophysics, Astronomy, and Space—Soviet-bloc Research in Geophysics, Astronomy, and Space. Office of Technical Services. Washington, D.C.

Space Sci.—Space Science. Silver Spring, Md.

Space Technology Labs., Inc., Research Bibliography—

Space Technology Labs, Inc., Translation—Space Technology Laboratories, Inc., Research Bibliography *and* Translation. Redondo Beach, Calif.

Stella—Stella. Budapest, Hungary.

Sterne—Die Sterne. Leipzig, Germany.

Sternenwelt—Sternenwelt. Munich, Germany.

Studia Geol. Polonica—Studia Geologica Polonica. Polska Akademia Nauk. Warsaw, Poland.

Sudan Notes and Records—Sudan Notes and Records. Khartoum, Sudan.

Svensk Naturvetensk.—Svensk Naturvetenskap. Stockholm, Sweden.

Svenska Vetensk.-akad. Handl.—Svenska Vetenskapsakademien. Handlingar. Stockholm, Sweden.

Tartu Univ., Geol.-Inst. Toimetused—Tartu University, Geoloogia-Instituudi, Toimetused. Tartu, U.S.S.R.

Tartu Univ., Lood. Seltsi, Aruand.—Tartu University, juures oleva Loodusuurijate Seltsi, Aruanded. Tartu, U.S.S.R.

Terra—Terra. Helsinki, Finland.

Texas Univ. Bull.—University of Texas, Bulletin. Austin, Tex.

Tschermaks Mineralog. Petrog. Mitt.—Tschermaks Mineralogische und Petrographische Mitteilungen. Leipzig, Germany.

Tulsa Geol. Soc. Digest—Tulsa Geological Society, Digest. Tulsa, Okla.

Umschau—Umschau. Frankfurt, Germany.

212–459—66——2

U.S. Air Force Cambridge Research Labs. Geophys. Paper—U.S. Air Force, Cambridge Research Laboratories, Geophysical Paper. Bedford, Mass.
U.S. Geol. Survey Bull.—
U.S. Geol. Survey Prof. Paper—
U.S. Geol. Survey Water-Supply and Irrigation Paper—
U.S. Geological Survey, Bulletin *and* Professional Paper *and* Water-Supply and Irrigation Paper. Washington, D.C.
U.S. Natl. Aeronautics and Space Adm. Tech. Translation—U.S. National Aeronautics and Space Administration, Technical Translation. Washington, D.C.
Universo—El Universo. Sociedad Astronómica de Mexico. México, D.F., Mexico.
Urania København—Urania. Urania Observatoriet. Copenhagen, Denmark.
Urania Kraków—Urania. Polskiego Towarzystwa Milóśników Astronomii. Kraków, Poland.
Vega—Vega. Boughton, Chester, England.
Ver. Vaterl. Naturk. Württemberg Jahresh.—Verein für vaterländische Naturkunde in Württemberg, Jahreshefte. Stuttgart, Germany.
Walkabout—Walkabout. Australian National Travel Association. Melbourne, Australia.
Washington Acad. Sci. Jour.—Washington Academy of Sciences, Journal. Washington, D.C.
Weltall—Weltall. Berlin, Germany.
Weltraumfahrt—Weltraumfahrt. Frankfurt, Germany.
West Texas Geol. Soc. Guidebook—West Texas Geological Society, Guidebook. Midland, Tex.
Wisconsin Acad. Sci. Trans.—Wisconsin Academy of Sciences, Transactions. Madison, Wis.
Zeitschr. Naturforschung—Zeitschrift für Naturforschung. Tübingen, Germany.
Zentralbl. Mineralogie—Zentralblatt für Mineralogie. Stuttgart, Germany.
Zentralbl. Mineralogie Geologie und Paläontologie—Zentralblatt für Mineralogie, Geologie und Paläontologie. Stuttgart, Germany.
Zvaigznota Debess—Zvaigznota Debess. Riga, Latvia.

BIBLIOGRAPHY

DISTRIBUTION AND GENERAL CHARACTERISTICS OF IMPACT STRUCTURES

Ref.

1 Albritton, C. C., Jr., and Boon, J. D., 1937, Meteoritic craters and structures; Pan-Am. Geologist, v. 68, p. 304–305.

2 Baldwin, R. B., 1963, The measure of the Moon: Chicago, Ill., Univ. of Chicago Press, 488 p.

Almost half this book is given to a comprehensive survey of sites of known or suspected impact origin. Most structures treated in the present bibliography are mentioned.

3 Barringer, R. W., 1964, World's meteorite craters, "astroblemes"; Meteoritics, v. 2, no. 2, p. 169–174.

This list was prompted by discussion at the 1960 meeting of the Meteoritical Society of the advisability of maintaining an official list of meteorite craters. Barringer gives location, size, and evidence for 27 "meteorite craters," 13 "suspected meteorite craters," and 12 "large fall sites."

Ref.

4 Beals, C. S., 1955, Problems of geophysics in the Canadian Arctic: Arctic, v. 7, nos. 3–4, p. 176–187.

5 ——— 1957, Comments concerning the J. E. Hill and J. J. Gilvarry article, "Application of the Baldwin crater relation to the scaling of explosion craters": Jour. Geophys. Research, v. 72, no. 2, p. 166.

6 ——— 1958a, Canadian meteorite craters: Royal Astron. Soc. Canada Jour., v. 52, p. 18–19.

7 ——— 1958b, Fossil meteorite craters: Sci. Am., v. 199, no. 1, p. 32–39.

8 ——— 1958c, A survey of terrestrial craters: Nature, v. 181, no. 4608, p. 559.

9 Beals, C. S. Ferguson, G. M., and Landau, A., 1956a, A search for lunar-type craters on photographs of the Canadian Shield: Astron. Jour., v. 61, no. 1238, p. 171.

10 ———1956b, A search for analogies between lunar and terrestrial topography on photographs of the Canadian Shield: Royal Astron. Soc. Canada Jour., v. 50, no. 5, p. 203–211; no. 6, p. 250–261; reprinted in Ottawa Dominion Observatory Contr., v. 2, no. 21, p. 203–211, 250–261.

11 Beals, C. S., and Innes, M. J. S., 1961, The study of fossil meteorite craters with the aid of geophysical and diamond drilling techniques, *in* Proceedings of the Geophysical Laboratory/Lawrence Radiation Laboratory Cratering Symposium, Washington, D.C., March 28–29, 1961: California Univ., Livermore, Lawrence Radiation Lab. Rept., UCRL–6438, pt. 1, paper C, 44 p. (Report prepared for U.S. Atomic Energy Commission.)

12 ——— 1964, Oproznaniye drevnikh meteoritnikh kraterov [Identification of ancient meteorite craters]: Meteoritika, no. 25, p. 3–39.

13 Beals, C. S., Innes, M. J. S., and Rottenberg, J. A., 1960, The search for fossil meteorite craters: Current Sci. [India], v. 29, p. 205–218, 249–262; reprinted in Ottawa Dominion Observatory Contr., v. 4, no. 4, 31 p.

14 ——— 1963, Fossil meteorite craters, *in* Middlehurst, Barbara, and Kuiper, G. P., eds., The Moon, meteorites, and comets—The solar system, vol. 4: Chicago, Ill., Univ. of Chicago Press, p. 235–284.

The authors point out that the existence of fossil craters was first suggested in connection with cryptovolcanic structures and review evidence for impact origin of eight structures in the Canadian Shield; they are particularly interested in the theory and mechanics of crater formation.

15 Boon, J. D., 1936, The impact of meteors: Field and Laboratory, v. 4, no. 2, p. 56–59.

16 ——— 1938, Meteorite craters and structures [abs.]: Geol. Soc. America Proc. 1937, p. 305–306.

Ref.

17 Boon, J. D., and Albritton, C. C., Jr., 1936, Meteorite craters and their possible relationship to "cryptovolcanic structures": Field and Laboratory, v. 5, no. 1, p. 1–9.

In three papers cited here (refs. 17, 18, 19), Boon and Albritton point out that the type of structure expected beneath large meteorite craters is strikingly similar to certain "cryptovolcanic structures" and that certain explosion structures previously attributed to volcanism might, in fact, be of meteoritic origin. (*See also* ref. 105.)

18 ——— 1937, Meteorite scars in ancient rocks: Field and Laboratory, v. 5, no. 2, p. 53–64.

This article attempts to show how underlying structures of meteorite craters might be preserved and to evaluate the meteoritic hypothesis as an explanation for the Flynn Creek, Sierra Madera, and Vredefort structures, previously designated as cryptovolcanic.

19 ——— 1938, Established and supposed examples of meteoritic craters and structures: Field and Laboratory, v. 6, no. 2, p. 44–56.

20 Bucher, W. H., 1936, Cryptovolcanic structures in the United States: Internat. Geol. Cong., 16th, Washington, D.C., 1933, Rept., v. 2, p. 1055–1084.

Cryptovolcanic structures, as a structural type, are "characterized by a nearly circular outline; a central uplift with intense structural derangement; and a marginal, ring-shaped depression with irregular and local faulting. Evidence of explosive action is seen in the intensely disordered structure and local brecciation of the central, uplifted portion; the presence (in two of the structures described) of peculiar fracture patterns, the 'shatter cones' and the presence and character of folding in the marginal zone." The structures are thought to be the result of a sudden liberation of pent-up volcanic gases.

21 ——— 1963a, Are cryptovolcanic structures due to meteorite impact?: Nature, v. 197, no. 4874, p. 1241–1245.

22 ——— 1963b, Cryptoexplosion structures caused from without or from within the Earth? ("astroblemes" or "geoblemes"): Am. Jour. Sci., v. 261, no. 7, p. 597–649.

Bucher reviews and evaluates developments in the cryptovolcanic-meteoritic hypothesis, with application to the Ries, Wells Creek, and Vredefort problems.

23 Bülow, Kurd von, 1937, Riesenmeteoriten und ihre Spuren im Antlitz der Erde [Great meteorites and their traces on Earth]: Kosmos [Stuttgart], v. 34, no. 1, p. 21–24.

24 Canadian Scientific Committee for Upper Mantle, International Upper Mantle Project, 1963, Meteorite crater studies, *in* Canadian progress report, June 1963: p. 36–39.

This report details work in progress by C. S. Beals and colleagues, of the Dominion Observatory, Ottawa.

Ref.

25 Chao, E. C. T., 1963, Meteorite impact, an astrogeologic phenomenon: Natl. Acad. Sci.-Natl. Research Council Pub. 1075, Nuclear Sci. Ser. Rept. no. 38, p. 219–232.

26 Cohen, A. J., 1963, Fossil meteorite craters: Natl. Acad. Sci.-Natl. Research Council Pub. 1075, Nuclear Sci. Ser. Rept. no. 38, p. 233–238.

27 Cohen, A. J., Bunch, T. E., and Reid, A. M., 1961, Coesite discoveries establish cryptovolcanics as fossil meteorite craters: Science, v. 134, no. 3490, p. 1624–1625.

28 Collins, A. F., 1959, Meteor craters: British Interplanetary Soc. Jour., v. 17, p. 99.

29 Currie, K. L., 1964, On the origin of some "recent" craters on the Canadian Shield: Meteoritics, v. 2, no. 2, p. 93–110.

This paper compares New Quebec, Clearwater Lakes, and Manicouagan and notes that none of the craters can be explained by the classical impact theory or by analogy with known volcanic areas.

30 Dachille, Frank, 1962, Interactions of the earth with very large meteorites: South Carolina Acad. Sci. Bull., no. 24, p. 1–19.

31 Dence, M. R., 1964, A comparative structural and petrographic study of probable Canadian meteorite craters: Meteoritics, v. 2, no. 3, p. 249–270.

32 Didcock, H. R., 1934, Meteorites in geological formations: British Astron. Assoc. Jour., v. 44, no. 4, p. 168–169.

33 Dietz, R. S., 1946, Geological structures possibly related to lunar craters: Pop. Astronomy, v. 54, p. 465–467.

34 ——— 1959a, Point d'impact des asteroids comme origine des bassins oceaniques—une hypothese [Asteroid impact as origin of ocean basins—a hypothesis]: France Centre Natl. Recherche Sci. Colloques Internat., no. 83, p. 265–275.

35 ——— 1959b, Shatter cones in cryptoexplosion structures (meteorite impact?): Jour. Geology, v. 67, no. 5, p. 496–505.

36 ——— 1960, Meteorite impact suggested by shatter cones in rock: Science, v. 131, no. 3416, p. 1781–1784.

The presence of shatter cones at Sierra Madera, Flynn Creek, and Serpent Mound is reviewed.

37 ——— 1961, Astroblemes: Sci. Am., v. 205, no. 2, p. 51–58.

"This newly coined word refers to ancient scars left in the earth's crust by huge meteorites. The evidence for such impacts is largely the high-pressure mineral coesite and 'shatter cones' in the rocks."

38 ——— 1963a, Astroblemes, ancient meteorite-impact structures on the Earth, *in* Middlehurst, Barbara, and Kuiper, G. P., eds., The Moon,

Ref.

meteorites, and comets—The solar system, vol. 4: Chicago, Ill., Univ. of Chicago Press, p. 285–300.

Dietz makes a case for shatter cones as a criterion for recognition of the formation of certain geologic structures by intense shock.

39 Dietz, R. S., 1963b, Cryptoexplosion structures, a discussion: Am. Jour. Sci., v. 261, no. 7, p. 650–664.

The author replies to the objections of W. H. Bucher (ref. 22) and discusses his objections to the concept that cryptoexplosion structures such as the Steinheim and Wells Creek type are "astroblemes."

40 Diggelen, J. van, 1954, Maankraters en meteoorkraters [Moon craters and meteor craters]: Meteoor, v. 10, p. 17–19.

41 Drejsin, R. L., 1952, Meteorites as a factor in formation of the Earth's relief: Meteoritika, no. 10, p. 110–111 [in Russian].

42 Eskola, Pentti, 1937, Meteorikraatereista [Meteorite craters]: Terra, v. 49, no. 1, p. 45–58.

43 Fisher, W. J., 1933, The penetration of iron meteorites into the ground: Natl. Acad. Sci. Proc., v. 19, p. 286–291.

44 ——— 1934, Excavated meteorites: Pop. Astronomy, v. 42, p. 501–504.

45 Flammarion, G. C., 1932, Le secret des pierres tombées du ciel [Secret of stones from the sky]: Astronomie, v. 46, p. 549–558.

46 Gale, S. I., 1949, Laboratory craters: Sky and Telescope, v. 8, no. 7, p. 174.

47 Garstang, R. H., 1958, Probable meteorite craters: British Astron. Assoc. Jour., v. 68, no. 2, p. 75–76.

48 Goguel, Jean, 1963, A hypothesis on the origin of the "cryptovolcanic structures" of the central platform of the United States: Am. Jour. Sci., v. 261, no. 7, p. 665–667.

Goguel proposes an alternate theory to that of Bucher (ref. 22) and Dietz (ref. 39). "If the hydraulic pressure of water and other fluids contained in a permeable formation should locally exceed the lithostatic pressure, the overlying strata would be lifted into an arch, but the fluid would rapidly escape and the arch would then collapse, producing the chaotic structure and the shatter cones observed."

49 Halliday, Ian, 1964, The variation in the frequency of meteorite impact with geographic latitude: Meteoritics, v. 2, no. 3, p. 271–278.

50 Halliday, Ian, and Griffin, A. A., 1964, Application of the scientific method to problems of crater recognition: Meteoritics, v. 2, no. 2, p. 79–84; reprinted in Ottawa Dominion Observatory Contr., v. 4, no. 10, p. 79–84.

51 Hardy, C. T., 1954, Major craters attributed to meteoritic impact: Am. Assoc. Petroleum Geologists Bull., v. 38, no. 5, p. 917–923.

This work briefly summarizes information on 12 craters.

Ref.

52 Harrison, E. R., 1960, Origin of the Pacific Basin—A meteorite impact hypothesis: Nature, v. 188, no. 4756, p. 1064–1067.

53 Hawkins, G. S., 1963, Impacts on the Earth and Moon: Nature, v. 197, no. 4869, p. 781.

54 Healy, P. W., LaPaz, Lincoln, and Leonard, F. C., 1953, On the identification of terrestrial meteorite craters: Royal Astron. Soc. Canada Jour., v. 47, p. 160–161; reviewed by E. J. Öpik in Irish Astron. Jour., v. 3, p. 29–30.

55 Heide, Fritz, 1933a, Meteoritenkrater [Meteorite craters]: Forschung u. Fortschr., v. 9, no. 26, p. 379–381.

56 ——— 1933b, Uber Riesenmeteoriten [On giant meteorites]: Chemie der Erde, v. 8, no. 1–2, p. 224–251.

57 ——— 1964, Meteorites, translated from the German by Edward Anders in collaboration with Eugene R. DuFresne: Chicago, Ill., Univ. of Chicago Press, 144 p.

58 Hennig, R., 1934, Meteorkrater auf der Erde—Eine neuentdeckte Naturerscheinung [Meteorite craters on the Earth—A newly discovered phenomenon of nature]: Geog. Wochenschr., v. 2, no. 28, p. 730–734.

59 Hey, M. H., 1957, Bombardment of the earth by meteors: Nature, v. 179, no. 4551, p. 121–124.

60 Heybrock, W., 1934, Zur Kenntnis von Meteoriten und Meteorkratern [Knowledge of meteorites and meteor craters]: Sterne, v. 14, p. 51–57.

61 Hoffleit, Dorrit, 1951a, Meteorite crater formation: Sky and Telescope, v. 10, no. 4, p. 87.

62 ——— 1951b, New meteorite craters?: Sky and Telescope, v. 11, no. 1, p. 2, 9.

63 Inglis, S. J., 1945, Lack of impact craters on the earth: Pop. Astronomy, v. 53, p. 520.

64 Innes, M. J. S., 1961, The use of gravity methods to study the underground structure and impact energy of meteorite craters: Jour. Geophys. Research, v. 66, no. 7, p. 2225–2239; reprinted in Ottawa Dominion Observatory Contr., v. 5, no. 6, 17 p.

Gravity data were used to calculate the mass deficiency and hence the amount of shattered rock under the Deep Bay, Brent, and Holleford Craters.

65 ——— 1964, Recent advances in meteoritic research at Dominion Observatory, Ottawa, Canada: Meteoritics, v. 2, no. 3, p. 219–242.

66 Irish Astronomical Journal, 1958, Meteor craters: Irish Astron. Jour., v. 5, p. 112–113.

67 ——— 1963, Meteor craters: Irish Astron. Jour., v. 6, p. 39.

Ref.
68 Kelly, A. O., 1963, Meteoritic kettle lakes—a consideration of their origin: Carlsbad, Calif., published privately, 29 p.

69 Kelly, A. O., and Dachille, Frank, 1953, Target, Earth—The role of large meteors in earth science: Pensacola, Fla., Pensacola Engraving Co., 263 p.

70 Kornhauser, Murray, 1958, Prediction of cratering caused by meteoroid impacts: Jour. Astronaut. Sci., v. 5, p. 58–63.

71 Krinov, E. L., 1960, Principles of meteoritics, translated from the Russian by Irene Vidziunas and edited by Harrison Brown: New York, Pergamon Press, 535 p.

In a short chapter on crater-producing meteorites, Krinov relates the problem of craters to the bigger problem of meteoritics.

72 ——— 1962, Meteoritnyye kratery na poverkhnosti zemli [Meteorite craters on the Earth's surface]: Meteoritika, no. 22, p. 3–30.

73 ——— 1963a, Meteorite craters on the Earth's surface, *in* Middlehurst, Barbara, and Kuiper, G. P., eds., The Moon, meteorites, and comets—The solar system, vol. 4: Chicago, Ill., Univ. of Chicago Press, p. 183–207.

Krinov discusses two types of meteorite craters (explosion and impact); he defines 14 structures as authentic craters, 10 as probable ones.

74 ——— 1963b, Meteoritnyye kratery na poverkhnosti zemli [Meteorite craters on the Earth's surface]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 11, p. 11–24 [with Estonian and English summaries].

75 LaPaz, Lincoln, 1941, Meteorite craters and the hypothesis of the existence of contraterrene meteorites: Pop. Astronomy, v. 49, p. 99–102.

76 ——— 1953, The discovery and interpretation of nickel-iron granules associated with meteorite craters: Royal Astron. Soc. Canada Jour., v. 47, p. 191–194.

77 Leonard, F. C., 1946, Authenticated meteorite craters of the world, *in* A catalog of provisional coordinate numbers for the meteorite falls of the world: New Mexico Univ. Pub. Meteoritics, no. 1, p. 54.

Eleven craters are given as "authentic."

78 Ley, Willy, 1937, How the moon got its craters—Experiments duplicate the scars on the face of the moon and support the evidence yielded by the earth's own meteor craters: Nat. History, v. 39, no. 4, p. 275–279.

79 McCall, G. J. H., 1964, Are cryptovolcanic structures due to meteoritic impact?: Nature, v. 201, no. 4916, p. 251–254.

McCall rejects Dietz's impact hypothesis, and adds arguments to support Bucher's interpretation of the Vredefort and other structures.

80 Nature, 1937, Meteorite craters: Nature, v. 140, no. 3549, p. 801.

Ref.

81 Nekrasov, I. A., and Raudonis, P. A., 1963, Meteoritnyye kratery [Meteorite craters]: Priroda, 1963, no. 1, p. 102–104; translated by E. R. Hope as Canada Directorate Sci. Inf. Service Translation 385R, 5 p.

82 Nininger, H. H., 1933a, "Meteor craters" vs. "steam blowouts": Mines Mag., v. 23, no. 12, p. 7–8; abs. in Pan-Am. Geologist, v. 60, no. 4, p. 308–310; 1934, Mining Rev., v. 36, no. 2, p. 9–11.

83 ——— 1933b, Our stone-pelted planet—A book about meteors and meteorites: Boston, Houghton Mifflin, 235 p.

84 ——— 1938, Observations and suggestions regarding meteorite craters [abs.]: Geol. Soc. America Bull., v. 49, no. 12, pt. 2, p. 1956.

85 ——— 1948, Geological significance of meteorites: Am. Jour. Sci., v. 246, no. 2, p. 101–108.

86 ——— 1952, Meteorite craters, *in* Out of the sky—An introduction to meteoritics: Denver, Colo., Univ. of Denver Press, p. 205–229.

This is a concise review of the development of scientific acceptance of the meteoritic theory and of opinion on eight craters currently believed to be meteoritic in origin.

87 Öpik, E. J., 1958, Meteor impact on solid surface: Irish Astron. Jour., v. 5, p. 14–33.

Taking the Barringer crater with its meteoric fragments as an example, Öpik reviews the physical conditions prevailing at high-velocity impact of a solid projectile into a solid surface.

88 ——— 1964, Circular depressions as suspected meteor craters: Irish Astron. Jour., v. 6, no. 5, p. 198–199.

Öpik has received letters citing craters in Maputaland, Northern Zululand; on North Andaman Island, Bay of Bengal (?); near Fairplay, Colo.; in New Mexico, near the Arizona border; and 112 km east of Winslow, Ariz.

89 Prior, G. T., 1953, Meteoritic craters, *in* Catalogue of meteorites [2d ed.], revised and enlarged by Max H. Hey: London, British Museum, p. 417–426.

Thirty-eight sites are mentioned here, with bibliographic detail.

90 Redman, R. O., 1932, Meteorite craters: Observatory, v. 55, p. 224–225.

91 Rinehart, J. S., 1950, Some observations on high-speed impact: Pop. Astronomy, v. 58, p. 458–464; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 299–305.

92 ——— 1962, Stresses associated with lunar landings: British Interplanetary Soc. Jour., v. 17, no. 12, p. 431–436.

93 Rosický, Vojtěch, 1934, O velikých povětroních [On large meteorites and their craters]: Priroda [Brno], v. 27, no. 7, p. 209–213.

Ref.

94. Rostoker, Norman, 1953, The formation of craters by high-speed particles: Meteoritics, v. 1, no. 1, p. 11–27.

95 Sandner, W., 1951, Verzeichnis der bis jetzt bekannten Meteorkrater [List of currently known meteorite craters]: Meteorbeobachter, 1951, no. 4, p. 4.

96 Scheffler, H., 1959, Crateros meteoriticos [Meteorite craters]: Universo, v. 13, p. 157–162.

97 Shoemaker, E. M., and Eggleton, R. E., 1961, Terrestrial features of impact origin, *in* Proceedings of the Geophysical Laboratory/Lawrence Radiation Laboratory Cratering Symposium, Washington, D.C., March 28–29, 1961: California Univ., Livermore, Lawrence Radiation Lab. Rept. UCRL–6438, pt. 1, paper A, 27 p. (Report prepared for U.S. Atomic Energy Commission.)

This summary is intended to help systematize the recognition and investigation of terrestrial impact structures and to serve as a guide to sources of data for the nonspecialist. Tables listing structures by type and an index map to location are included.

98 Šimon, R., 1957, A register of meteorite crater localities: Časopis, v. 7, p. 71–72 [in Czechoslovakian].

99 Spencer, L. J., 1932, Meteorite craters: Nature, v. 129, no. 3265, p. 781–784.

100 ——— 1933, Meteorite craters as topographical features on the earth's surface: Geog. Jour. [London], v. 81, no. 3, p. 227–248; reprinted in Smithsonian Inst. Ann. Rept. 1933, p. 307–325.

In one of the earliest surveys of meteorite craters as a geological problem, Spencer discusses eight examples, five of which he concludes to be meteoritic.

101 ——— 1934, Meteorite craters: Geologists' Assoc. London Proc., v. 45, pt. 4, p. 407–411.

102 Struve, Otto, 1956, Meteorites, and their effects: Sky and Telescope, v. 15, no. 7, pp. 292–295.

103 Szczepkowski, B., 1957, O proporcjach rozmiarów kraterów meteorytowych [On the proportions of the dimensions of meteor craters]: Urania Kraków, v. 28, p. 100–103.

104 Trusheim, F., 1940, Fliegerbomben und Geologie—kleine geologische Beobachtungen an Fliegerbomben-Einschlagen [Aerial bombs and geology—a small geological observation on aerial bomb impacts]: Natur und Volk, v. 70, no. 7, p. 317–321.

105 Washburne, C. W., 1937, Salt domes, meteor craters, and cryptovolcanic structures: Am. Assoc. Petroleum Geologists Bull., v. 21, no. 5, p. 629–630.

Washburne replies to Boon and Albritton (ref. 17).

Ref.

106 Wills, R. G., 1936, Some effects of meteorites (presidential address): Liverpool Geol. Soc. Proc., v. 17, pt. 1, p. 2–9.

107 Wylie, C. C., 1933, On the formation of meteoric craters: Pop. Astronomy, v. 41, p. 211–214.

108 ——— 1934, Meteoric craters, meteors, and bullets: Pop. Astronomy, v. 42, p. 469–471.

IMPACT SITES

AL HADIDA CRATERS, SAUDI ARABIA

(*See* Wabar Craters)

AL UMCHAIMIN CRATER, IRAQ

(Lat 32°50′ N.; long 39°50′ E. Category 5)

109 Merriam, Richard, and Holwerda, J. G., 1957, Al Umchaimin, a crater of possible meteoritic origin in western 'Iraq: Geog. Jour. [London], v. 123, pt. 2, p. 231–233.

Merriam tentatively attributes the origin of this extensive, nearly circular depression to meteoritic impact rather than to solution processes, wind erosion, or volcanism.

AMAK ISLAND CRATER, ALEUTIAN ISLANDS, ALASKA

(Lat 55°44′ N.; long 163°09′ W. Category 6)

110 Hoffleit, Dorrit, 1947, Alaskan crater: Sky and Telescope, v. 6, no. 8, p. 7.

111 LaPaz, Lincoln, 1947, A possible meteorite crater in the Aleutians: Pop. Astronomy, v. 55, p. 156–168; reprinted in Meteorit. Soc. Contr., v. 4, no. 1, p. 20–31.

Letters from Charles Keenan, of the U.S. Army, describe a crater on Amak Island; LaPaz, interested in a program to search for new meteorite craters by air, speculates on the effectiveness of such a program.

AMGUID CRATER, ALGERIA

(Lat 26°31′ N.; long 5°21′ E. Category 6)

112 Karpoff, Roman, 1953, The meteorite crater of Talemzane in southern Algeria (CN=±0041,333): Meteoritics, v. 1, no. 1, p. 31–38.

AOUELLOUL CRATER, MAURITANIA

(Lat 20°15′ N.; long 12°41′ W. Category 2)

113 Monod, Théodore, 1954, Sur quelques accidents circulaire où cratériformes du Sahara occidental [On some circular or crateriform irregularities of the western Sahara]: Internat. Geol. Cong., 19th, Algiers 1952, Comptes rendus, pt. 20, p. 85–93.

Five structures are discussed (Aouelloul, Temimichat-Ghallaman, Tenoumer, Richât, and Semsiyât); Aouelloul is considered the only probable meteorite crater.

Ref.
114 Monod, Théodore, and Pourquié, A., 1951, Le cratère d'Aouelloul (Adrar, Sahara occidental) [The Aouelloul crater (Adrar, western Sahara)]: Inst. Français Afrique Noire Bull., v. 13, no. 2, p. 294–311.

115 Smith, W. C., and Hey, M. H., 1952, The silica-glass from the crater of Aouelloul (Adrar, western Sahara): Inst. Français Afrique Noire Bull., v. 14, no. 3, p. 762–776.

Fragments of silica glass found in and near the crater are considered the products of fusion of meteoritic material. Chemical analyses are included.

See also ref. 73.

ARNHEM LAND CRATER, NORTHERN TERRITORY, AUSTRALIA

(Lat 13°10′ S.; long 135°40′ E. Category 5)

116 Wilson, A. F., 1947, Depressions resembling meteorite craters: Royal Geog. Soc. Australasia, South Australian Branch, Proc., v. 48, p. 25.

See also ref. 89.

ASHANTI CRATER, GHANA

(*See* Lake Bosumtwi)

BAGHDAD CRATERS, IRAQ

(Lat 33°20′ N.; long 44°25′ E. Two craters. Category 6)

117 Knetsch, G., 1954, Zwei neue Meteoritenkrater? [Two new meteorite craters?]: Sterne, v. 30, p. 66.

BARRINGER CRATER, COCONINO COUNTY, ARIZ.

(Alternate name: Meteor Crater. Lat 35°02′ N.; long 111°01′ W. Category 1)

118 Adler, Isidore, and Dwornik, E. J., 1961, Electronprobe analysis of schreibersite (rhabdite) in the Canyon Diablo meteorite: U.S. Geol. Survey Prof. Paper 424-B, Art. 112, p. B263–B265.

119 Almor, F., 1962, Meteoros y meteoritos [Meteors and meteorites]: Aster [Barcelona], v. 14, no. 123, p. 94–97.

120 Barnes, W. C., 1934, The "discovery" of Meteor Crater: Mus. Northern Arizona Mus. Notes, v. 7, no. 2, p. 5–8.

121 Barringer, D. M., 1905, Coon Mountain and its crater: Acad. Nat. Sci. Philadelphia Proc., v. 57, p. 861–886.

In this paper Barringer refutes the steam explosion theory for the origin of Meteor Crater, as accepted by Gilbert (ref. 162), and details his reasons for supporting a meteoritic hypothesis. This conviction, further stated in supplementary articles (refs. 123, 124), was aided by W. F. Magie (ref. 197) and B. C. Tilghman (ref. 249).

Ref.
122 Barringer, D. M., 1909, Meteor Crater (formerly called Coon Mountain or Coon Butte) in northern central Arizona: Published privately, 24 p., 18 pls.

123 ——— 1914, Further notes on Meteor Crater, Arizona: Acad. Nat. Sci. Philadelphia Proc., v. 66, p. 556–565.

124 ——— 1924, Further notes on Meteor Crater in northern central Arizona: Acad. Nat. Sci. Philadelphia Proc., v. 76, p. 275–278.

125 ——— 1926, Exploration at Meteor Crater: Eng. Mining Jour.-Press, v. 121, no. 2, p. 59; no. 11, p. 450–451; no. 19, p. 771.

126 Barringer, D. M., and Tilghman, B. C., 1906, The geology of Coon Butte, Arizona [abs.]: Science, new ser., v. 24, p. 370–371; 1907, Am. Assoc. Adv. Sci. Proc., v. 56–57, p. 271.

127 Barringer, D. M., Jr., 1927, The most fascinating spot on earth (Meteor Crater, Arizona): Sci. Am., v. 137, no. 1, p. 52–54; no. 2, p. 144–146; no. 3, p. 244–246.

128 ——— 1931, The Barringer meteorite: Science, new ser., v. 73, p. 66–67.

129 Beals, C. S., and Millman, P. M., 1959, A comparison of subsurface materials from two meteorite craters: Astron. Jour., v. 64, no. 1273, p. 324.

130 Bingham, W. F., 1937, Summary of findings from exploration, geophysical survey, and test-drilling at Meteor Crater, Arizona: Pan-Am. Geologist, v. 68, no. 3, p. 196–198; abs. in Pan-Am. Geologist, v. 68, no. 4, p. 306; 1938, Geol. Soc. America Proc. 1937, p. 305.

131 Bjork, R. L., 1961, Analysis of the formation of Meteor Crater, Arizona, a preliminary report: Jour. Geophys. Research, v. 66, no. 10, p. 3379–3387; also in Proceedings of the Geophysical Laboratory/Lawrence Radiation Laboratory Cratering Symposium, Washington, D.C., March 28–29, 1961, California Univ., Livermore, Lawrence Radiation Lab. Rept. UCRL–6438, pt. 2, paper M, 21 p. (Report prepared for U.S. Atomic Energy Commission.)

A theoretical study was made of the cratering process accompanying the impact of a 12,000-ton iron projectile on a semi-infinite half space of soft rock at a velocity of 30 kilometers per second, the constituents and velocity approximating those involved in the formation of Meteor Crater. Bjork concludes that the meteorite had a mass between 30,000 and 194,000 tons, the range being due to uncertainty concerning the impact velocity.

132 Blackwelder, Eliot, 1932, The age of Meteor Crater: Science, new ser., v. 76, p. 557–560; 1933, abs. in Pan-Am. Geologist, v. 58, no. 1, p. 69–70; Geol. Soc. America Bull., v. 44, no. 1, p. 156.

The author estimates the age of Meteor Crater at 40,000 to 75,000 years.

133 ——— 1946a, Meteor Crater, Arizona: Science, v. 104, no. 2689, p. 38–39.

Ref.

134 Blackwelder, Eliot, 1946b, Origin of the Arizona meteorite crater: Pop. Astronomy, v. 54, p. 427–428; 1947, reprinted in Soc. Research on Meteorites Contr., v. 3, no. 5, p. 284–285.

135 ———1953, Crater Mound-Meteor Crater: Am. Assoc. Petroleum Geologists Bull., v. 37, no. 11, p. 2577–2580.

136 Boot, D. H., 1920, Meteor Mountain: Iowa Acad. Sci. Proc., v. 26, p. 379–383.

137 Boutwell, W. D., 1928, The mysterious tomb of a giant meteorite: Natl. Geog. Mag., v. 53, no. 6, p. 720–730.

138 Buddhue, J. D., 1945, Some observations on the soil near the Canyon Diablo, Arizona, meteorite crater [abs.]: Pop. Astronomy, v. 53, p. 287–289; reprinted in Soc. Research on Meteorites Contr., v. 3, no. 4, p. 203.

139 ———1948, A sieve analysis of crushed sandstone from the Canyon Diablo, Arizona, meteorite crater: Pop. Astronomy, v. 56, p. 387–389; reprinted in Meteorit. Soc. Contr., v. 4, no. 2, p. 134–135.

140 ———1950, New chemical analyses of the Canyon Diablo, Arizona, and Arispe, Sonora, Mexico, siderites: Pop. Astronomy, v. 58, p. 190; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 258–259.

141 Bunch, T. E., and Cohen, A. J., 1964, Shock deformation of quartz from two meteorite craters: Geol. Soc. America Bull., v. 75, no. 12, p. 1263–1266.

142 Campbell, W. W., 1920, Notes on the problem of lunar craters (including notes on Meteor Crater, Arizona): Astron. Soc. Pacific Pub., v. 32, no. 186, p. 126–138.

143 Chao, E. C. T., Fahey, J. J., Littler, Janet, and Milton, D. J., 1962, Stishovite, SiO_2, a very high pressure new mineral from Meteor Crater, Arizona: Jour. Geophys. Research, v. 67, no. 1, p. 419–421.

Stishovite, a recently synthesized high-density polymorph of SiO_2, has been identified in the coesite-bearing Coconino Sandstone of Meteor Crater.

144 Chao, E. C. T., Shoemaker, E. M., and Madsen, B. M., 1960, First natural occurrence of coesite: Science, v. 132, no. 3421, p. 220–222.

The natural occurrence of coesite has an important bearing on the recognition of meteorite impact craters in quartz-bearing geological formations.

145 Colvocoresses, G. M., 1936, Meteor Crater: Rocks and Minerals, v. 11, no. 8, p. 113–117.

146 Darton, N. H., 1916, Explosion craters: Sci. Monthly, v. 3, no. 5, p. 417–430.

147 ———1945, Crater Mound, Arizona [abs.]: Geol. Soc. America Bull., v. 56, no. 12, pt. 2, p. 1154; 1946, Assoc. Am. Geographers Annals, v. 36, no. 1, p. 86.

148 Davison, J. M., 1910, A contribution to the problem of Coon Butte: Science, new ser., v. 32, p. 724–726.

Ref.
149 Dellenbaugh, F. S., 1931, Meteor Butte: Science, new ser., v. 73, no. 1880, p. 38–39.

150 Dickey, D. D., and Johnson, R. B., 1961, Influence of natural fractures on the shape of explosion-produced craters, *in* Short papers in the geologic and hydrologic sciences: U.S. Geol. Survey Prof. Paper 424–C, p. C361–C363.

151 Dodge, N. N., 1955, The most interesting spot on earth: Pacific Discovery, v. 8, no. 4, p. 24–26.

152 Dublin, J., 1932, A la recherche du Dieu de feu des Navajoes [In search of the Navajo god of fire]: Astronomie, v. 46, p. 94–96.

153 Fairchild, H. L., 1907a, A meteoric crater of Arizona: Internat. Geol. Cong., 10th, Mexico 1906, Comptes rendus, p. 147–151.

154 ——— 1907b, Origin of Meteor Crater (Coon Butte), Arizona: Geol. Soc. America Bull., v. 18, p. 493–504.

155 ——— 1930, Nature and fate of the Meteor Crater bolide: Science, new ser., v. 72, no. 1871, p. 463–467.

Fairchild concludes that the Barringer meteorite was a large stony mass, with metallic inclusions.

156 ——— 1931, Nature and fate of the Meteor Crater bolide: Royal Astron. Soc. Canada Jour., v. 25, p. 17–26.

157 Fisher, Clyde, 1934, Where a comet struck the earth: Nat. History, v. 34, no. 8, p. 754–762.

158 Foote, A. E., 1891, Geological features of the meteoric locality in Arizona: Acad. Nat. Sci. Philadelphia Proc., v. 43, p. 407.

159 ——— 1892, A new locality for meteoric iron with a preliminary notice of the discovery of diamonds in the iron: Am. Assoc. Adv. Sci. Proc., v. 40, p. 279–283; 1893, abs. in Am. Geologist, v. 8, no. 3, p. 192.

160 Foster, G. E., 1955, A siderite found inside the Barringer meteorite crater: Meteoritics, v. 1, no. 3, p. 358–359.

161 ——— 1957, The Barringer (Arizona) meteorite crater: Meteor Crater, Ariz., published privately, 31 p.

162 Gilbert, G. K., 1896, The origin of hypotheses, illustrated by the discussion of a topographic problem: Science, new ser., v. 3, p. 1–13.

A classic, this paper provides the first detailed geological description of the Arizona crater.

163 Gilbert, G. K., and Baker, Marcus, 1891, A meteoric crater: Astron. Soc. Pacific Pub., v. 4, no. 21, p. 37.

In a telegram to the San Francisco Examiner, Tuesday, December 1, 1891, Gilbert and Baker describe the first examination of Meteor Crater and the finding of meteoric iron.

Ref.
164 Guild, F. N., 1907, Coon Mountain crater: Science, new ser., v. 26, p. 24–25.

165 Hack, J. T., 1942, The changing environment of the Hopi Indians of Arizona: Harvard Univ., Peabody Mus. Am. Archeology and Ethnology Papers, v. 35, no. 1, 85 p.

166 Hager, Dorsey, 1926, Meteor Crater [Arizona]: Eng. Mining Jour.-Press, v. 12, no. 9, p. 374.

167 ——— 1949, Crater Mound ("Meteor Crater"), Arizona—Is its origin geologic or meteoritic? [abs.]: Pop. Astronomy, v. 57, p. 457–458; reprinted in Meteorit. Soc. Contr., v. 4, no. 3, p. 223–224.

168 ——— 1953, Crater Mound (Meteor Crater), Arizona, a geologic feature: Am. Assoc. Petroleum Geologists Bull., v. 37, no. 4, p. 821–857; discussion by E. Blackwelder and reply by author, no. 11, p. 2577–2579; comment by C. T. Hardy, no. 11, p. 2580; 1956, additional notes by author, v. 40, no. 1, p. 161–162.

The writer finds the crater and the mound to be two separate, but interrelated, geologic features and supports a geologic, rather than meteoritic, origin for the mound.

169 ——— 1954, Notes on Crater Mound in answer to some points raised by H. H. Nininger: Am. Jour. Sci., v. 252, no. 11, p. 695–697.

170 Harding, Norman, and Miller, Roswell, 3d, 1953, A gravity survey of Meteor Crater, Arizona [abs.]: Geophysics, v. 18, no. 3, p. 742.

171 Hardy, C. T., 1953, Structural dissimilarity of Meteor Crater and Odessa meteorite crater: Am. Assoc. Petroleum Geologists Bull., v. 37, no. 11, p. 2580.

172 Hastings, J. B., 1909, Meteor Crater: Mining Sci. Press, v. 98, p. 523–525.

173 Heald, W. F., 1959, Meteor Crater: Arizona Highways, v. 35, no. 4, p. 6–9.

174 Hoffleit, Dorrit, 1943, Meteor Crater meteorite: Sky and Telescope, v. 2, no. 5, p. 6.

175 ——— 1949a, Meteor Crater is square: Sky and Telescope, v. 8, no. 3, p. 62.

176 ——— 1949b. Meteorites in the rim of Meteor Crater: Sky and Telescope, v. 9, no. 1, p. 10.

177 ——— 1955, Ill wind at Meteor Crater: Sky and Telescope, v. 14, no. 10, p. 418.

178 Holland, L. F. S., 1925, Meteor Mountain crater, Arizona: Eng. Mining Jour.-Press, v. 119, no. 6, p. 253–254.

179 Jakosky, J. J., 1932, Geophysical methods locate meteorite: Eng. Mining Jour., v. 133, no. 7, p. 392–393.

Ref.

180 Jakosky, J. J., Wilson, C. H., and Daly, J. W., 1932, Geophysical examination of Meteor Crater, Arizona: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 97, p. 63–98.

181 Johnson, G. W., 1960, Note on estimating the energies of the Arizona and Ungava meteorite craters: California Univ., Livermore, Lawrence Radiation Lab. Rept. UCRL–6227, 18 p. (Report prepared for U.S. Atomic Energy Commission.)

Crater dimensions derived from the high explosive experience of the Plowshare program are used to estimate equivalent depths of burst and energies of the Arizona and New Quebec Craters.

182 Keyes, C. R., 1910, Coon Butte and meteoritic falls of the desert [abs.]: Geol. Soc. America Bull., v. 21, no. 12, p. 773–774.

183 ——— 1911, Volcanic phenomena of Coon Butte region, Arizona [abs.]: Iowa Acad. Sci. Proc., v. 18, p. 99–100; also in Science, new ser., v. 34, no. 862, p. 29.

184 Kreins, E. R., 1953, Results of a systematic study of the ratio of meteorite to oxidite at the Barringer meteorite crater of Arizona: Meteoritics, v. 1, no. 1, p. 29–30.

185 Ksanda, C. J., and Henderson, E. P., 1939, Identification of diamond in the Canyon Diablo iron: Am. Mineralogist, v. 24, no. 11, p. 677–680.

186 Kutscher, M., 1938, Neues vom Arizonakrater [News from the Arizona crater]: Weltall, v. 38, p. 282–283.

187 LaPaz, Lincoln, 1948a, A comet strikes the earth—review: Meteorit. Soc. Contr., v. 4, no. 2, p. 103–104.

188 ——— 1948b, An announcement concerning future explorations at the Canyon Diablo, Arizona, meteorite crater; Pop. Astronomy, v. 56, p. 559–560; reprinted in Meteorit. Soc. Contr., v. 4, no. 2, p. 164–165.

189 ——— 1950, A preliminary report on Indian ruins discovered near the crest of the Barringer meteorite crater, Arizona: Pop. Astronomy, v. 58, p. 400–401; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 285–286,

190 ——— 1950, The discovery and interpretation of nickel-iron granules associated with meteorite craters: Royal Astron. Soc. Canada Jour., v. 47, p. 191–194.

191 Lassovszky, K., 1930, On the meteor crater in Arizona: Stella, v. 5, p. 48–50 [in Hungarian].

192 Leonard, F. C., 1946, "Crater Mound, Arizona": Pop. Astronomy, v. 54, p. 152–153; reprinted in Soc. Research on Meteorites Contr., v. 3, no. 5, p. 249.

193 ——— 1950, The name of the Barringer meteorite crater of Arizona: Pop. Astronomy, v. 58, p. 469; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 309.

212–459—66——3

Ref.

194 Lewis, W. S., 1946, Origin of the crater: Desert Mag., v. 9, no. 11, p. 29.

195 Longwell, C. R., 1931, Meteor Crater is not a limestone sink: Science, new ser., v. 73, no. 1887, p. 234–235.

196 Lundberg, Hans, 1938, Some geophysical data on the Meteor Crater in Arizona [abs.]: Geol. Soc. America Bull., v. 49, no. 12, pt. 2, p. 1953.

197 Magie, W. F., 1910, Physical notes on Meteor Crater, Arizona: Am. Philos. Soc. Proc., v. 49, p. 41–48; abs. in Science, new ser., v. 31, no. 805, p. 872–873.

198 Mallet, J. W., 1908, A stony meteorite from Coon Butte, Arizona: Am. Jour. Sci., ser. 4, v. 21, p. 347–355.

199 Margerie, Emmanuel de, 1913, Deux accidents cratériformes—Crater Lake (Oreg.) et Meteor Crater (Ariz.) [Two crateriform irregularities—Crater Lake (Oreg.) and Meteor Crater (Ariz.)]: Annales Géographie, v. 22, p. 172–184.

200 Mead, C. W., Chao, E. C. T., and Littler, Janet, 1963, Metallic spheroids from Meteor Crater, Arizona, *in* Astrogeologic studies annual progress report, August 25, 1961, to August 24, 1962: U.S. Geol. Survey open-file rept., pt. C, p. 150–162; abs. in Am. Geophys. Union Trans., v. 44, no. 1, p. 87.

201 Meinecke, Franz, 1909, Der Meteorkrater von Canyon Diablo in Arizona und seine Bedeutung fur die Entstehung der Mondkrater [The Canyon Diablo meteor crater and its significance for the origin of Moon craters]: Naturwiss. Wochenschr., new ser., v. 8, p. 801–810.

202 Merrill, G. P., 1908, The meteor crater of Canyon Diablo, Arizona—Its history, origin, and associated meteoritic irons: Smithsonian Misc. Colln., v. 50, p. 461–498.

203 ——— 1909, Coon Butte or Meteor Crater [abs.]: Science, new ser., v. 29, no. 736, p. 239–240.

204 ——— 1920, A retrospective view of the origin of Meteor Crater, Arizona: Astron. Soc. Pacific Pub., v. 32, no. 189, p. 259–264.

205 Merrill, G. P., and Tassin, Wirt, 1907, Contributions to the study of Canyon Diablo meteorites: Smithsonian Misc. Colln., v. 50, p. 203–215.

206 Monnig, O. E., 1941, The Schertz, Guadalupe County, Texas, meteorite proved identical with Canyon Diablo, Arizona: Pop. Astronomy, v. 49, p. 560–562.

207 Mulder, M. E., 1911, De explosive van meteoren en het outstaan van den meteorkrater van Canyon Diablo [Explosion of meteorites and the origin of the Canyon Diablo meteor crater]: Ingenieur, v. 26, p. 880–899.

Ref.

208 Namba, Munetosi, 1954, Geophysical study of Arizona meteorite crater, *in* Some studies on volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 2, no. 1, p. 85–89.

209 Nature, 1924, The Meteor Crater of Arizona : Nature, v. 115, p. 244.

210 ——— 1958, Arizona meteorite crater: Nature, v. 181, no. 4626, p. 1777.

211 Newton, A. M., 1946, A cosmic bomb destroys a civilization [abs.]: Pop. Astronomy, v. 54, p. 484; reprinted in Soc. Research on Meteorites Contr., v. 3, no. 5, p. 294.

212 Niermeyer, J. F., 1913, Kraters in sedimentair Gesteente in Arizona en Nieuw-Mexico [Craters in sedimentary rocks in Arizona and New Mexico]: Nederlandsch Natuur- en Geneeskundig Congres, 14th, Delft 1913, Hand 14, p. 430–436.

213 ——— 1939, Diamonds in Canyon Diablo, Ariz., meteorites: Pop. Astronomy, v. 47, p. 504–507; reprinted in Soc. Research on Meteorites Contr., v. 2, no. 2, p. 142–145.

214 ——— 1940, A new type of nickel-iron meteorite from the vicinity of the Arizona meteorite crater: Pop. Astronomy, v. 48, p. 328–332.

215 ——— 1947, The Barringer meteorite crater [abs.]: Pop. Astronomy, v. 55, p. 49; reprinted in Meteorit. Soc. Contr., v. 4, no. 1, p. 19.

216 ——— 1949a, Meteorites in as well as on the crater rim: Pop. Astronomy, v. 57, p. 333–334.

217 ——— 1949b, A new type of magnetometer survey of Barringer meteorite crater: Pop. Astronomy, v. 57, p. 1–5.

218 Nininger, H. H., 1949c, Oxidation studies at Barringer crater—Metal-center pellets and oxide droplets: Am. Philos. Soc. Yearbook 1949, p. 126–133.

219 ——— 1950, Structure and composition of Canyon Diablo meteorites as related to zonal distribution of fragments: Pop. Astronomy, v. 58, p. 169–173.

220 ——— 1951a, Condensation globules at Meteor Crater: Science, v. 113, no. 2948, p. 755–756.

221 ——— 1951b, A résumé of researches at the Arizona meteorite crater: Sci. Monthly, v. 72, no. 2, p. 75–86.

222 ——— 1953, Symmetries and asymmetries in Barringer Crater: Earth Sci., v. 7, no. 1, p. 17–19.

223 ——— 1954a, Further notes on metallic spheroids at the Arizona meteorite crater [abs.]: Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1397–1398.

Ref.

224 Nininger, H. H., 1954b, Impactite slag at Barringer Crater: Am. Jour. Sci., v. 252, no. 5, p. 277–290; discussion by D. Hager and reply by author in no. 11, p. 695–700.

This paper, with its attendant discussions, represents a difference of opinion with Dorsey Hager. (*See* ref. 168.)

225 ——— 1956, Arizona's meteorite crater, past, present, future: Sedona, Ariz., Am. Meteorite Mus., 232 p.

Nininger describes researches and surveys made since the discovery of the crater and critically reviews findings to date.

226 Norton, O. R., 1959, The Barringer meteorite crater: Griffith Observer, v. 23, no. 5, p. 62–73.

227 Pickering, W. H., 1909, The chance of collision with a comet, iron meteorites and Coon Butte: Pop. Astronomy, v. 17, p. 329–339.

228 Rinehart, J. S., 1957a, Distribution of meteoritic debris about the Arizona meteorite crater [abs.]: Astron. Jour., v. 62, no. 1247, p. 96.

229 ——— 1957b, A soil survey around the Barringer crater: Sky and Telescope, v. 16, no. 8, p. 366–369.

230 ——— 1958a, Distribution of meteoritic debris about the Arizona meteorite crater: Smithsonian Contr. Astrophysics, v. 2, p. 145–160; discussion by H. C. Dake in Mineralogist, v. 26, no. 9, p. 216, 218.

The object of this survey was to systematically investigate distribution of minuscule bits of material scattered through the mantle of soil surrounding the crater, with a view to fixing more closely the mass of the meteorite and the direction of its flight.

231 ——— 1958b, On the nature of the meteoritic debris at the Arizona meteorite crater [abs.]: Astron. Jour., v. 63, no. 1262, p. 310.

232 Roach, C. H., Johnson, G. R., McGrath, J. G., and Sterrett, T. S., 1962, Thermoluminescence investigations at Meteor Crater, Arizona, *in* Short papers in geology, hydrology, and topography: U.S. Geol. Survey Prof. Paper 450–D, p. D98–D103.

233 Robie, E. H., 1928, The Meteor Crater project [Arizona]: Eng. Mining Jour., v. 125, no. 21, p. 850–852.

234 Rogers, A. F., 1930, A unique occurrence of lechatelierite or silica glass: Am. Jour. Sci., 5th ser., v. 19, p. 195–202.

235 Rohleder, H. P. T., 1933, Meteor-Krater (Arizona)—Salzpfanne (Transvaal)—Steinheimer Becken [Meteor Crater (Arizona)—Salzpfanne (Transvaal)—Steinheim Basin]: Deutsche Geol. Gesell. Zeitschr., v. 85, p. 463–468.

236 Russell, H. N., 1931, Meteor Crater: Mus. Northern Arizona Mus. Notes, v. 4, no. 3, p. 1–3.

Ref.

237 Shoemaker, E. M., 1959, Structure and Quaternary stratigraphy of Meteor Crater, Arizona, in the light of shock-wave mechanics [abs.]: Geol. Soc. America Bull., v. 70, no. 12, pt. 2, p. 1748.

238 ——— 1960, Penetration mechanics of high velocity meteorites, illustrated by Meteor Crater, Arizona: Internat. Geol. Cong., 21st, Copenhagen 1960, Rept., pt. 18, p. 418–434.

"Studies of craters formed by detonation of nuclear devices at shallow depth in alluvium show that structures of the crater rims are related to the depth of explosion and the yield of the device. The penetration mechanics for Meteor Crater, Arizona, are derived by scaling relationships from nuclear explosion craters, based on detailed geologic mapping of both types of craters."

239 ——— 1963, Impact mechanics at Meteor Crater, Arizona, *in* Middlehurst, Barbara, and Kuiper, G. P., eds., The Moon, meteorites, and comets—The solar system, vol. 4: Chicago, Ill., Univ. of Chicago Press, p. 301–336.

This paper reverses the usual procedure of attacking the cratering problem on theoretical grounds and applying the results to Meteor Crater by deducing requirements for theory from the geology of the crater and its structural similarity to a nuclear explosion crater.

240 Sjogren, Hjalmar, 1911, Om kratorn vid Canyon Diablo, Arizona [On the Canyon Diablo Crater, Arizona]: Svenska Vetensk.-akad. Handl., Stockholm Arsbok 1911, p. 237–262.

241 Skerrett, R. G., 1929, Meteor Crater again a scene of activity: Compressed Air Mag. v. 34, no. 6, pt. 1, p. 2,773–2,778; pt. 2, p. 2,809–2,813.

242 Sky and Telescope, 1956, At Barringer meteorite crater: Sky and Telescope, v. 16, no. 1, p. 21.

243 Struve, Otto, 1959, The making of the Barringer meteorite crater: Sky and Telescope, v. 18, no. 4, p. 187–189.

244 Stutzer, Otto, 1936a, Der Meteor-Krater in Arizona [The meteor crater in Arizona]: Natur und Volk, v. 66, no. 9, p. 442–453.

245 ——— 1936b, "Meteor Crater" (Arizona) u. Nördlinger Ries ["Meteor Crater" (Arizona) and Nördlingen Ries]: Deutsche Geol. Gesell. Zeitschr., v. 88, p. 510–523; discussion by E. Hennig, A. Bentz, and Wilhelm Ahrens, p. 588–591.

246 Thomas, Kirby, 1924, Exploring in Arizona for a super meteorite: Arizona Mining Jour., v. 8, no. 4, p. 16.

247 Thomson, Elihu, 1912, The fall of a meteorite: Am. Acad. Arts Sci. Proc., v. 47, p. 721–733.

248 Thurmond, F. L., 1926, Is there a Canyon Diablo meteorite?: Eng. Mining Jour., v. 122, no. 21, p. 817–818.

Ref.
249 Tilghman, B. C., 1906, Coon Butte, Arizona: Acad. Nat. Sci. Philadelphia Proc., v. 57, p. 887–914.

250 Tilghman, B. C., and Barringer, D. M., 1906, The geology of Coon Butte, Arizona [abs.]: Science, new ser., v. 24, p. 370–371; 1907, Am. Assoc. Adv. Sci. Proc., v. 57, p. 271.

251 Walton, Matt, 1959, The Arizona meteor crater controversy: Royal Astron. Soc. Canada Jour., v. 53, p. 162–171.

252 Watson, Fletcher, Jr., 1936, Meteor Crater: Pop. Astronomy, v. 44, p. 2–17.

253 Wilson, C. H., 1932, Drilling proves existence of meteoric mass: Mining Jour. (Phoenix), v. 15, no. 23, p. 7.

254 Wylie, C. C., 1934, Meteor craters, meteors, and bullets: Pop. Astronomy, v. 42, p. 469–471.

255 ——— 1943a, Applying mine-crater formulas to Meteor Crater in Arizona: Pop. Astronomy, v. 51, p. 220–222.

256 ——— 1943b, Calculations on the probable mass of the object which formed Meteor Crater: Pop. Astronomy, v. 51, p. 97–99.

Wylie, using data from explosion and World War I mine craters, proposes a meteorite 35 to 50 feet in diameter, with a mass of 5,000 to 15,000 tons.

257 ——— 1943c, Second note on the probable mass of the object which formed Meteor Crater: Pop. Astronomy, v. 51, p. 158–161.

258 Zimmerman, W. W., 1948, The non-circularity of the Canyon Diablo, Arizona, meteorite crater: Pop. Astronomy, v. 56, p. 496–498; reprinted in Meteorit. Soc. Contr., v. 4, no. 2, p. 148–150.

Aerial photographs show Meteor Crater to be square, with rounded corners.

See also refs. 38, 82, 87, 100.

BASRA CRATER, IRAQ

(Lat 30° N.; long 47° E. Category 6)

See ref. 57.

BOXHOLE CRATER, NORTHERN TERRITORY, AUSTRALIA

(Lat 22°37′ S.; long 135°12′ E. Category 1)

259 Madigan, C. T., 1937, The Boxhole crater and the Huckitta meteorite (central Australia): Royal Soc. South Australia Trans. and Proc., v. 61, p. 187–190.

The Boxhole Crater was discovered in June 1937. No impactite was found; iron fragments found closely resemble those from the Henbury Crater.

Ref.
260 Madigan, C. T., 1940, The Boxhole meteoritic iron, central Australia: Mineralog. Mag. [London], v. 25, no. 168, p. 481–486.

See also ref. 73.

BRENT CRATER, NIPISSING COUNTY, ONTARIO

(Lat 46°04′ N.; long 78°29′ W. Category 4)

261 Beck, A. E., and Logis, Z., 1964, Terrestrial flow of heat in the Brent crater: Nature, v. 201, no. 4917, p. 383.

262 Innes, M. J. S., and Beals, C. S., 1961, Profile of the fossil crater at Brent, Ontario: Royal Astron. Soc. Canada Jour., v. 55, p. 258.

263 Millman, P. M., Liberty, B. A., Clark, J. F., Willmore, P. L., and Innes, M. J. S., 1960, The Brent crater: Ottawa Dominion Observatory Pub., v. 24, no. 1, 43 p.

Brent Crater was first observed on aerial photographs as a circular depression approximately 2 miles in diameter. Geological, magnetic, and seismic investigations lead the authors to conclude that the crater was formed by meteorite impact, possibly in late Precambrian time, and that its present state is a consequence of subsequent erosion and deposition within it of Paleozoic sediments.

See also refs. 14, 31, 64.

CAMPO DEL CIELO CRATERS, CHACO, ARGENTINA

(Lat 27°40′ S.; long 61°40′ W. Category 1)

264 Alvarez, Antenor, 1926, El meteorito del Chaco [The Chaco meteorite]: Buenos Aires, Jacobo Peuser, 222 p.

This is a detailed history of early explorations.

265 Milton, D. J., 1964, The Campo del Cielo meteorite crater field, Argentina, *in* Astrogeologic studies annual progress report, August 25, 1962, to July 1, 1963: U.S. Geol. Survey open-file rept., pt. B, p. 91–97.

This is a preliminary report on the 1962 expedition which made the first detailed examination of the Campo del Cielo meteorite field.

266 Nágera, J. J., 1926, Los hoyos del Campo del Cielo y el meteorito [The Campo del Cielo craters and meteorite]: Argentina Dir. Minas Geol. Pub. no. 19, p. 1–9, pls. 1–23.

Nágera describes and includes photographs of four craters which he believed to be artificial excavations.

267 Parish, Woodbine, 1833, Notice as to the supposed identity of the large mass of meteoric iron now in the British Museum, with the celebrated Otumpa iron described by Rubin de Celis in the Philosophical Transactions for 1786: Royal Soc. London Philos. Trans., v. 128, p. 53–54.

Ref.

268 Rubin de Celis, Michael, 1788, Of a mass of native iron, found in South America: Royal Soc. London Philos. Trans., v. 128, p. 369–372.

See also refs. 73, 100.

CAROLINA BAYS, SOUTHEASTERN COAST UNITED STATES

(Lat 33°45′ N., long 78°45′ W. (center of area). Category 5)

269 Barringer, Brandon, 1947, Observations on the Carolina "craters" or "bays": Pop. Astronomy, v. 55, p. 215–217.

270 Cooke, C. W., 1933, Discussion of the origin of the supposed meteorite scars of South Carolina: Jour. Geology, v. 42, no. 1, p. 88–96; abs. in Washington Acad. Sci. Jour., v. 23, no. 12, p. 569–570.

271 ——— 1936, Geology of the coastal plain of South Carolina: U.S. Geol. Survey Bull. 867, 196 p.

272 ——— 1940, Elliptical bays in South Carolina and the shape of eddies: Jour. Geology, v. 48, no. 2, p. 205–211.

273 ——— 1943, Elliptical bays: Jour. Geology, v. 51, no. 6, p. 419, 427.

274 ——— 1954, Carolina Bays and the shapes of eddies: U.S. Geol. Survey Prof. Paper 254–I, p. 195–207.

275 Grant, Chapman, 1948, Meteoritic origin of the "Carolina Bays" questioned: Pop. Astronomy, v. 56, p. 511–527.

276 ——— 1955, Shape of the Sikhote-Alinsk meteoritic craters in relation to the "Carolina Bays": Pop. Astronomy, v. 59, p. 225.

277 Hoffleit, Dorrit, 1946, Origin of the Carolina Bays: Sky and Telescope, v. 5, no. 5, p. 11.

278 Johnson, D. W., 1936, Origin of the supposed meteorite scars of South Carolina: Science, new ser., v. 84, no. 2166, p. 15–18; 1934, abs. in Science, new ser., v. 79, no. 2055, p. 461; 1936, Geol. Soc. America Proc. 1935, p. 83–84.

279 ——— 1942, The origin of the Carolina Bays: New York, Columbia Univ. Press, 341 p.

280 ——— 1944, Mysterious craters of the Carolina coast: Am. Scientist, v. 32, no. 1, p. 1–22.

281 Johnson, W. R., Jr., Straley, H. W., 3d, and Straley, H. W., 4th, 1953, Depth to anomaly source for Carolina Bays: Georgia Geol. Survey Bull. 60, p. 125–130.

282 Jones, W. H., 1952, The mysterious Carolina Bays: Mineralogist, v. 20, no. 5, p. 195–199.

Ref.
283 Kelley, A. O., 1951, The origin of the Carolina Bays and the oriented lakes of Alaska: Pop. Astronomy, v. 59, p. 199–205.

284 LeGrand, H. E., 1951, Streamlining the Carolina Bays [abs.]: Geol. Soc. America Bull., v. 62, no. 12, pt. 2, p. 1459; Pop. Astronomy, v. 59, p. 539; reprinted in Meteorit. Soc. Contr., v. 5, no. 1, p. 98.

285 Leonard, F. C., 1947, On the origin of the Carolina "bays": Pop. Astronomy, v. 55, p. 276.

286 MacCarthy, G. R., 1937, The Carolina Bays: Geol. Soc. America Bull., v. 48, no. 9, p. 1211–1225.

MacCarthy presents six conclusions from a University of North Carolina survey. He feels that the Carolina Bays were formed by shock waves accompanying the meteorite shower and that the meteoritic materials were mostly volatilized. An analogy is made to the 1908 Tunguska event.

287 Melton, F. A., 1934, Reply to article by C. W. Cooke, "Discussion of the origin of the supposed meteorite scars": Jour. Geology, v. 42, no. 1, p. 97–104.

288 ——— 1938a, Possible late Cretaceous origin of the Carolina "bays" [abs.]: Geol. Soc. America Bull., v. 49, no. 12, pt. 2, p. 1954.

289 ——— 1938b, Geological theories on the origin of the Carolina "bays" [abs.]: Geol. Soc. America Proc. 1937, p. 312.

290 ——— 1950, The Carolina "bays": Jour. Geology, v. 58, no. 2, p. 128–134.

291 Melton, F. A., and Schriever, William, 1933a, The Carolina "bays"—Are they meteorite scars?: Jour. Geology, v. 41, no. 1, p. 52–66; abs. in Geol. Soc. America Bull., v. 44, no. 1, p. 94; Sci. Am., v. 149, no. 3, p. 106–107, and no. 4, p. 158–159, 188–189; Tulsa Geol. Soc. Digest, 1933, p. 12.

This is the first suggestion of a cosmic origin for the bays; the authors propose a theory involving impact by a large cluster of meteorites.

292 ——— 1933b, Meteoric scars in the Carolinas: Am. Astron. Soc. Pub., v. 7, p. 179.

293 Odum, H. T., 1952, The Carolina Bays and a Pleistocene weather map: Am. Jour. Sci., v. 250, no. 4, p. 263–270.

294 Prouty, W. F., 1934, The Carolina Bays: Elisha Mitchell Sci. Soc. Jour., v. 50, no. 1–2, p. 59–60.

295 ——— 1935, The Carolina Bays and elliptical lake basins: Jour. Geology, v. 43, no. 4, p. 200–207.

296 ——— 1936, Further evidence in regard to the origin of Carolina Bays and elliptical lake basins: Geol. Soc. America Proc. 1935, p. 96–97.

297 ——— 1938, Later evidence concerning the meteoritic origin of Carolina Bays [abs.]: Science, v. 88, no. 2290, p. 476–477.

Ref.
298 Prouty, W. F., 1948, A reply to an article by Mr. Brandon Barringer on the origin of the "Carolina Bays": Pop. Astronomy, v. 56, p. 499–501.

299 ——— 1950, Origin of Carolina Bays: Pop. Astronomy, v. 58, p. 17–21.

300 ——— 1952, Carolina Bays and their origin: Geol. Soc. America Bull., v. 63, no. 2, p. 167–224.

This is the final article of a series in which Prouty develops a modified meteoritic theory for the origin of the Carolina Bays.

301 Prouty, W. F., MacCarthy, G. R., and Alexander, J. A., 1933, Some magnetometer observations in the coastal plain area of South Carolina: Elisha Mitchell Sci. Soc. Jour., v. 49, no. 1, p. 20–21.

302 Prouty, W. F., and Straley, H. W., 3d, 1938, Further studies of Carolina Bays: Geol. Soc. America Proc. 1937, p. 104–105.

303 Robertson, E. C., 1962, The Carolina Bays and emergence of the coastal plain of the Carolinas and Georgia, *in* Short papers in geology and hydrology: U.S. Geol. Survey Prof. Paper 450–C, p. C87–C90.

304 Royal Astronomical Society of Canada, 1936, The Carolina Bays and their supposed meteoric origin: Royal Astron. Soc. Canada Jour., v. 30, p. 57–60.

305 Schriever, William, 1951, On the origin of the Carolina Bays: Am. Geophys. Union Trans., v. 32, no. 1, p. 87–95; discussion by J. S. Rinehart, 1952, in v. 33, no. 1, p. 126–127.

306 Straley, H. W., 3d, and Straley, Wilt, 1954, Depth to the anomaly source of Carolina Bays: Meteoritics, v. 1, no. 2, p. 207.

307 Wells, B. W., and Boyce, S. G., 1953, Carolina Bays—Additional data on their origin, age and history: Elisha Mitchell Sci. Soc. Jour., v. 69, no. 2, p. 119–141.

308 Wylie, C. C., 1933, Iron meteorites and Carolina "bays": Pop. Astronomy, v. 41, p. 410–412.

CARSWELL LAKE STRUCTURE, SASKATCHEWAN

(Lat 58°27′ N.; long 109°30′ W. Category 6)

See ref. 14.

The authors point out that this structure shows the kind of deformation expected for a meteorite crater formed in sedimentary rock.

309 Fahrig, W. F., 1961, The geology of the Athabasca formation: Canada Geol. Survey Bull. 68, 41 p.

In describing the general geology of the Carswell formation, Fahrig tentatively classifies the lake feature as a "cryptovolcanic" structure.

See also refs. 13, 65.

CAVE SPRING HOLLOW, TENN.

(*See* Wells Creek area)

CHINGE SITE, TUVA AUTONOMOUS REGION, U.S.S.R.

(Lat 51° N.; long 94° E. Category 6)

Ref.

See ref. 73.

Krinov lists the Chinge site as a "probable meteorite crater," although no crater or traces of it have been found. He draws attention to the original shape of the meteorite samples.

310 Lutskiy, Valeriy, 1963, Expedition to seek supermeteorite: Kommunist [Yerevan], August 18, p. 3 [in Russian]; translated abstract titled "Expedition to see crater of Chinga meteorite," Soviet-bloc Research in Geophysics, Astronomy, and Space, no. 72, p. 29.

CHUBB CRATER, QUEBEC

(*See* New Quebec Crater)

CLEARWATER LAKES, QUEBEC

(Lat 56°10′ N.; long 74°20′ W. Two craters. Category 2)

311 Dence, M. R., Innes, M. J. S., and Beals, C. S., 1963, New meteor crater: Space Sci., v. 13, no. 1, p. 8.

312 Explorers Journal, 1954, Much larger crater than Chubb believed to exist in area N.E. of Hudson Bay post of Great Whale: Explorers Jour., v. 32, no. 1–2, p. 15.

313 Heywood, W. W., Brett, S. E., Currie, K. L., and Eade, K. E., 1958, La Grande-Lac Bienville: Canada Geol. Survey Map 23–1958.

314 Kranck, S. H., 1951, On the geology of the east coast of Hudson Bay and James Bay: Acta Geog., v. 11, no. 2, p. 1–71.

315 Kranck, S. H., and Sinclair, G. W., 1963, Clearwater Lake, New Quebec: Canada Geol. Survey Bull. 100, 25 p.

Clearwater Lakes consist of two circular depressions located on a highland of Precambrian granitic gneiss. Geological evidence suggests that the lakes are of volcanic-tectonic origin; the structure of the islands suggest that they represent volcanoes, formed by extrusion of lava along a circular fracture, probably concurrent with caldera collapse.

316 McIntyre, D. B., 1962, Impact metamorphism at Clearwater Lake, Quebec [abs.]: Jour. Geophys. Research, v. 67, no. 4, p. 1647.

During a 1958 gravity survey east of Hudson Bay, a Dominion Observatory party collected unusual metamorphic rocks on islands in Clearwater Lakes; they consider these rocks to be the product of meteorite impact.

317 Sky and Telescope, 1963, Two more ancient Canadian meteorite craters: Sky and Telescope, v. 26, no. 4, p. 198.

See also refs. 14, 29.

CRATER ELEGANTE, SONORA, MEXICO

(Lat 32°40′ N.; long 112°55′ W. Category 5)

Ref.
318 Kelly, A. O., 1952, Mysterious Crater Elegante: Sci. Monthly, v. 74, no. 5, p. 291–296.

319 Leonard, F. C., 1952, Crater Elegante—A caldera: Royal Astron. Soc. Canada Jour., v. 46, p. 252.

CRESTONE CRATER, SAGUACHE COUNTY, COLO.

(Alternate name: San Luis Maria Baca Grant Crater. Lat 38°52′ N.; long 105°39′ W. Category 5)

See ref. 3.

CROOKED CREEK STRUCTURE, CRAWFORD COUNTY, MO.

(Lat 37°50′ N.; long 91°23′ W. Category 4)

320 Amstutz, G. C., 1960, Polygonal and ring tectonic patterns in the Precambrian and Paleozoic of Missouri, U.S.A.: Eclogae Geol. Helvetiae, v. 52, no. 2, p. 904–913.

321 ——— 1964, Impact, cryptoexplosion or diapiric movements?: Kansas Acad. Sci. Trans., v. 67, no. 2, p. 343–356.

322 Fox, J. H., Allen, V. T., and Heinrich, Ross, 1954, Crooked Creek "cryptovolcanic" structure, Steelville, Missouri [abs.]: Geol. Soc. America Bull., v. 65, no. 12, pt. 2, p. 1252–1253.

323 Hendricks, H. E., 1954, The geology of the Steelville quadrangle, Missouri: Missouri Geol. Survey and Water Resources [Rept.], 2d ser., v. 36, 88 p.

Detailed mapping suggests impact as the most probable origin of the Crooked Creek structure.

324 Kilsgaard, T. H., Heyl, A. V., and Brock, M. R., 1963, The Crooked Creek disturbance, southeast Missouri, *in* Short papers in geology, hydrology, and topography: U.S. Geol. Survey Prof. Paper 450–E, p. E14–E19.

The authors detail evidence which suggests that the Crooked Creek disturbance originated from a subterranean gaseous explosion.

See also ref. 13.

DALGARANGA CRATER, WESTERN AUSTRALIA

(Lat 27°45′ S.; long 117°05′ E. Category 1)

325 Huss, G. I., 1962, Australia's Dalgaranga crater: Mineralogist, v. 30, no. 9/10, p. 4–7; no. 11/12, p. 12–14, 16.

This article, together with the Nininger and Huss report (ref. 327), describes the first scientific examination of the Dalgaranga Crater. The unusual character and variety of structures hitherto unknown in connection with other meteorite craters is discussed. The meteorite is judged to be largely stony; the age of the crater is estimated to be 25,000 years.

Ref.
326 Nininger, H. H., 1959, Another meteorite crater studied: Science, v. 130, no. 3384, p. 1251–1252.

327 Nininger, H. H., and Huss, G. I., 1960, The unique meteorite crater at Dalgaranga, Western Australia: Mineralog. Mag. [London], v. 32, no. 251, p. 619–639.

328 Simpson, E. S., 1938, Some new and little-known meteorites found in Western Australia: Mineralog. Mag. [London], v. 25, no. 163, p. 157–171.

This report, based on observations of G. E. Willard of the Dalgaranga Station, became the basis for the description of the Dalgaranga Crater and meteorite.

See also ref. 73.

DECATURVILLE DISTURBANCE, CAMDEN COUNTY, MO.

(Lat 37°54′ N.; long 92°43′ W. Category 4)

329 Krishnaswamy, D. S., and Amstutz, G. C., 1960, Geology of the Decaturville disturbance in Missouri [abs.]: Geol. Soc. America Bull., v. 71, no. 12, pt. 2, p. 1910.

"The tectonic history and the presence of the pegmatite(s) appear to support the conclusion that the Decaturville disturbance may be caused by polygonal or ring tectonic movements in the basement, connected with or caused by igneous activity."

330 Shepard, E. M., 1904, Spring system of the Decaturville Dome, Camden County, Missouri: U.S. Geol. Survey Water-Supply and Irrigation Paper 110, p. 113–125.

See also refs. 2, 26, 321.

DEEP BAY, REINDEER LAKE, SASKATCHEWAN

(Lat 56°24′ N.; long 103°00′ W. Category 6)

331 Innes, M. J. S., 1957a, A possible meteorite crater at Deep Bay, Saskatchewan: Royal Astron. Soc. Canada Jour., v. 51, p. 235–240; reprinted in Ottawa Dominion Observatory Contr., v. 3, no. 8, 8 p.

Deep Bay, the southeastern part of Reindeer Lake, is a circular depression with an average diameter of about 8½ miles and a depth, from highest point on the rim to lake bed, of about 1,130 feet. Evidence strongly suggests that it was formed by explosion.

332 ——— 1957b, A possible meteorite crater at Deep Bay, Saskatchewan: Astron. Jour., v. 62, no. 1247, p. 92–93.

333 ——— 1959, A gravity investigation of the Deep Bay crater [abs.]: Royal Soc. Canada Minutes Proc., 3d ser., v. 53, app. C, p. 20.

Ref.
334 Innes, M. J. S., Pearson, W. J., and Geuer, J. W., 1964, The Deep Bay crater: Ottawa Dominion Observatory Pub., v. 31, no. 2, 52 p.

"Topographical, geological and geophysical studies, combined with the results of diamond drilling strongly indicate an origin by meteoritic impact, and lend no support to the thesis that the Deep Bay depression is geologically or structurally controlled."

See also refs. 6, 14, 64, 65.

DES PLAINES DISTURBANCE, COOK COUNTY, ILL.

(Lat 42°02′ N.; long 87°56′ W. Category 6)

335 Emrich, G. H., and Bergstrom, R. E., 1959, Intense faulting at Des Plaines, northeastern Illinois [abs.]: Geol. Soc. America Bull., v. 70, no. 12, pt. 2, p. 1596.

336 ——— 1962, Des Plaines disturbance, northeastern Illinois: Geol. Soc. America Bull., v. 73, no. 8, p. 959–968.

The Des Plaines disturbance is here called a "cryptoexplosion structure" —a term implying no specific explosion mechanism. Drilling of wells has yielded data about structural movement which, with information of a negative gravity anomaly, lead the authors to suggest that the disturbance is the "root" of an old impact structure.

337 Suter, Max, Bergstrom, R. E., Smith, H. F., Emrich, G. H., Walton, W. C., and Larson, T. E., 1959, Preliminary report on ground-water resources of the Chicago region, Illinois: Illinois Water Survey Cooperative Ground-Water Rept. 1, 89 p.

DUCKWATER CRATER, NYE COUNTY, NEV.

(Lat 38°50′ N.; long 115°50′ W. Category 5)

338 Rinehart, J. S., and Elvey, C. T., 1951, A possible meteorite crater near Duckwater, Nye County, Nevada (ECN=±1157,387): Pop. Astronomy, v. 59, p. 209–211; reprinted in Meteorit. Soc. Contr., v. 5, no. 1, p. 44–45.

A crater, 225 feet in diameter and from 10 to 15 feet deep, was investigated. The authors found no meteoritic material but cannot ascribe origin of this crater to a nonimpact cause.

See also ref. 97.

DYCUS DISTURBANCE, JACKSON COUNTY, TENN.

(Lat 36°22′ N.; long 85°45′ W. Category 6)

See ref. 97.

Shoemaker and Eggleton include this structure in their study primarily on evidence presented by R. M. Mitchum, Jr., in an M.S. thesis, Vanderbilt University, 1951. Actually, Mitchum finds difficulty with both cryptovolcanic and meteoritic hypotheses.

DZIOUA CRATERS, ALGERIA

(Lat 33°19′ N.; long 5°17′ W. Category 6)

Ref.

See ref. 120.

ELLEF RINGNES ISLAND CRATERS, NORTHWEST TERRITORIES, CANADA

(Lat. 78°30′ N.; long 102°30′ W. Four craters. Category 6)

339 Brown, I. C., 1951, Circular structures in the Arctic Islands: Am. Jour. Sci., v. 249, no. 11, p. 785–794.

EYRE PENINSULA CRATERS, SOUTH AUSTRALIA

(Lat 34° S.; long 136° E. Category 5)

See ref. 89.

FAUGÈRES CRATERS, FRANCE

(*See* Hérault Craters)

FLYNN CREEK STRUCTURE, JACKSON COUNTY, TENN.

(Lat 36°17′ N.; long 85°40′ W. Category 4)

340 Conant, L. C., and Swanson, V. E., 1961, Chattanooga shale and related rocks of central Tennessee and nearby areas: U.S. Geol. Survey Prof. Paper 357, 91 p.

341 Roddy, D. J., 1963, Flynn Creek structure, Tennessee, *in* Astrogeologic studies annual progress report, August 25, 1961, to August 24, 1962: U.S. Geol. Survey open-file rept., pt. B, p. 118–126.

This and the following are preliminary reports on fieldwork in progress.

342 ——— 1964a, Geologic section across the Flynn Creek structure, *in* Astrogeologic studies annual progress report, August 25, 1962, to July 1, 1963: U.S. Geol. Survey open-file rept., pt B, p. 53–76.

343 ——— 1964b, Recent investigations of the Flynn Creek structure, with a section on geophysical studies by Shawn Biehler and D. J. Roddy, *in* Astrogeologic studies annual progress report, July 1, 1963, to July 1, 1964: U.S. Geol. Survey open-file rept., pt. B, p. 163–180.

344 Wilson, C. W., Jr., 1948, Channels and channel-filling sediments of Richmond age in south-central Tennessee: Geol. Soc. America Bull., v. 59, no. 8, p. 733–766.

345 Wilson, C. W., Jr., and Born, K. E., 1936, The Flynn Creek disturbance, Jackson County, Tennessee: Jour. Geology, v. 44, no. 7, p. 815–835.

Data accumulated on this small, intensely disturbed area indicate a cryptovolcanic origin.

See also refs. 18, 20, 36.

FRANKTOWN CRATER, ONTARIO

(Lat 45°03′ N.; long 76°04′ W. Category 5)

Ref.

See ref. 14.

Drilling results have substantially eliminated a meteoritic origin for the Franktown Crater.

GLASFORD STRUCTURE, PEORIA COUNTY, ILL.

(Lat 40°35′ N.; long 89°49′ W. Category 4)

346 Buschbach, T. C., and Ryan, Robert, 1963, Ordovician explosion structure at Glasford, Illinois: Am. Assoc. Petroleum Geologists Bull., v. 47, no. 12, p. 2015–2022.

The authors interpret this dome, about 2½ miles in diameter, to be an astrobleme.

GLOVER BLUFF STRUCTURE, MARQUETTE COUNTY, WIS.

(Lat 44°11′ N.; long 89°22′ W. Category 6)

347 Ekern, G. L., and Thwaites, F. T., 1930, The Glover Bluff structure, a disturbed area in the Paleozoics of Wisconsin: Wisconsin Acad. Sci. Trans., v. 25, p. 89–97.

This is the rewrite of an M.S. thesis which Ekern presented to the University of Wisconsin in 1928. Origin of the Glover Bluff structure remains unsettled.

GULF OF ST. LAWRENCE ARC, CANADA

(Lat 47°06′ N.; long 63°03′ W. Category 6)

348 Willmore, P. L., and Scheidegger, A. E., 1956, Seismic observations in the Gulf of St. Lawrence, *in* Canadian Comm. Oceanography, Ocean floors around Canada: Royal Soc. Canada Trans., 3d ser., v. 50, p. 21–38; reprinted in Ottawa Dominion Observatory Contr., v. 1, no. 30, p. 3–19.

The program described here was part of an organized search for craters in the Canadian Shield. The survey found dimensions of the gulf to be consistent with the meteorite explosion hypothesis but found no striking geologic evidence of an explosion.

See also ref. 14.

GWARKUH CRATER, BALUCHISTAN, IRAN

(Lat 28°30′ N.; long 60°40′ E. Category 5)

349 Dyer, R. E. H., 1921, The raiders of the Sarhad: London, H. F. and G. Witherby, p. 85–86.

The author relates how he was shown the crater first in 1916. At that time it measured 150 feet long, 120 feet wide, and 50 feet deep.

350 Heybrock, W., 1933, Der Meteorkrater von Gwarkuh [The Gwarkuh meteor crater]: Sterne, 1933, p. 134–136.

Ref.
351 Skrine, C. P., 1931, The highlands of Persian Baluchistan: Geog. Jour. [London], v. 78, no. 4, p. 328.

See ref. 100.

Spencer has examined writings and photographs of Dyer (ref. 349) and Skrine (ref. 351) and does not consider this feature a likely meteorite crater.

HAGENS FJORD CRATERS, GREENLAND

(Lat 81°45′ N.; long 28°15′ W. Category 6)

352 Ellitsgaard-Rasmussen, K., 1954, Meteoric shower in North East Greenland?: Dansk Geol. Foren. Meddel., v. 12, no. 4, p. 433–435; also in Copenhagen Univ. Mus. Mineralogie et Geologie Commun. Geol., no. 63, p. 433–435.

HAVILAND CRATER, KIOWA COUNTY, KANS.

(Lat 37°35′ N.; long 99°10′ W. Category 1)

353 Hay, Robert, 1893, Additional note on the Brenham meteorite: Kansas Acad. Sci. Trans., v. 13, p. 75.

354 Heybrock, W., 1950, Der Haviland-Meteor-Krater in USA [The Haviland meteor crater, U.S.A.]: Sterne, v. 26, p. 32.

355 Huntington, O. W., 1891, The Prehistoric and Kiowa County pallasites: Am. Acad. Arts Sci. Proc., v. 26, p. 1–12.

356 Kunz, G. F., 1890, On the group of meteorites recently discovered in Brenham Township, Kiowa County, Kansas: New York Acad. Sci. Trans., v. 9, p. 186–194.

357 Monnig, O. E., 1948, Some real meteorite finds at Brenham Township, Kiowa County, Kansas: Pop. Astronomy, v. 56, p. 47–48; reprinted in Soc. Research on Meteorites Contr., v. 4, no. 2, p. 92–94.

358 Nininger, H. H., 1938, Further notes on the excavation of the Haviland, Kiowa County, Kansas, meteorite crater [abs.]: Pop. Astronomy, v. 46, p. 110; Geol. Soc. America Proc. 1937, p. 313; reprinted in Soc. Research on Meteorites Contr., v. 2, no. 1, p. 13–14.

These notes supplement Nininger and Figgins (ref. 359).

359 Nininger, H. H., and Figgins, J. D., 1933, The excavation of a meteorite crater near Haviland, Kiowa County, Kansas: Colorado Mus. Nat. History Proc., v. 12, p. 9–15.

Meteorites were first discovered in the Haviland area in 1885, and subsequently examined by Kunz (ref. 356), Winchell and Dodge (ref. 360), and Hay (ref. 353). Nininger first drew attention to the crater in 1925; here he and Figgins discuss distribution of fragments within the crater.

Ref.

360 Winchell, N. H., and Dodge, J. A., 1890, The Brenham, Kiowa County, Kansas, meteorites: Am. Geologist, v. 5, no. 5, p. 309–312; v. 6, no. 6, p. 370–377.

See also ref. 73.

HEBRON CRATER, LABRADOR

(*see* Merewether Crater)

HENBURY CRATERS, NORTHERN TERRITORY, AUSTRALIA

(Lat 24°34′ S.; long 133°10′ E. Thirteen craters. Category 1)

361 Alderman, A. R., 1932a, The Henbury (central Australia) meteoric iron: South Australian Mus. Rec., v. 4, no. 4, p. 555–563.

362 ——— 1932b, The meteorite craters at Henbury, central Australia, with addendum by L. J. Spencer: Mineralog. Mag. [London], v. 23, no. 136, p. 19–32; reprinted in Smithsonian Inst. Ann. Rept. 1932, p. 223–234.

This article reports the first scientific expedition to Henbury. Alderman describes the locale and meteoritic material found there, points out similarities and differences between these craters and Meteor Crater, and suggests directions future study should take.

363 Bartrum, C. O., 1932, The meteorite craters at Henbury, central Australia: British Astron. Assoc. Jour., v. 41, no. 4, p. 263–264.

364 Bedford, R., 1934, Surface markings of the Henbury meteorites: Nature, v. 133, no. 3363, p. 575.

365 Goel, P. S., and Kohman, T. P., 1962, Cosmogenic carbon-14 in meteorites and terrestrial ages of "finds" and craters: Science, v. 136, no. 3519, p. 875–876.

Measurements show the Henbury irons to have a terrestrial age of $\leqq$7000 years.

366 Milton, D. J., and Michel, F. C., 1964, Geology of Crater no. 3, Henbury, Australia, *in* Astrogeologic studies annual progress report, July 1, 1963, to July 1, 1964: U.S. Geol. Survey open-file rept., pt. B, p. 146–162.

367 Rayner, J. M., 1938, The Henbury meteorite craters and geophysical prospecting: Australian Jour. Sci., v. 1, p. 93–94.

368 ——— 1939, Examination of the Henbury meteorite craters by the methods of applied geophysics: Australian and New Zealand Assoc. Adv. Sci. Rept., v. 24, p. 72–78.

A magnetic survey of 12 craters is discussed. It appears, from the absence of magnetic anomalies of a type that would arise from large meteorites at likely depth, that the craters were formed by excavating action of an explosive impact.

369 ———1939?, Geophysical report on the Henbury meteorite craters, central Australia: Australia Aerial Geol. and Geophys. Survey of Northern Australia, Rept., Northern Territory, no. 42, 7 p.

Ref.
370 Royal Astronomical Society of Canada, 1934, The Henbury meteorite craters in Australia: Royal Astron. Soc. Canada Jour., v. 28, p. 277–278.

371 Spencer, L. J., 1932, Meteoric iron and silica-glass from the meteorite craters of Henbury (central Australia) and Wabar (Arabia), with chemical analysis by M. H. Hey: Mineralog. Mag. [London], v. 23, no. 142 p. 387–404.

"At Henbury there is a much better development of the meteoric iron, while at Wabar the silica-glass predominates."

372 Taylor, S. R., and Kolbe, P., 1964, Henbury impact glass—parent material and behavior of volatile elements during melting: Nature, v. 203, no. 4843, p. 390–391.

See also ref. 73.

HÉRAULT CRATERS, FRANCE

(Alternate names: Faugères Craters, Le Clot, Montagne Noire.
Lat 43°32′ N.; long 3°08′ E. Six craters. Category 6)

373 Beals, C. S., 1964, A re-examination of the craters in the Faugères-Cabrerolles region of southern France: Meteoritics, v. 2, no. 2, p. 85–91; reprinted in Ottawa Dominion Observatory Contr., v. 4, no. 11, p. 85–91.

Comparison of five of the six known craters in this region, including Le Clot, with four craters of established meteoritic origin provided insufficient evidence to consider them as impact structures.

374 Dewhirst, D. W., 1952, More meteorite craters: British Astron. Assoc. Jour., v. 63, p. 51–52.

375 Gèze, Bernard, and Cailleux, André, 1950, Existence probable de cratères météoriques à Cabrerolles et à Faugères (Hérault) [Probable existence of meteoritic craters at Cabrerolles and Faugères (Hérault)]: Acad. Sci. [Paris] Comptes Rendus, v. 230, no. 17, p. 1534–1536.

Two surveyors report and favor a meteoric origin for six depressions in southern France. The largest, Le Clot, was first noticed on an aerial photograph.

376 Hoffleit, Dorrit, 1952, More meteor craters: Sky and Telescope, v. 11, no. 6, p. 134.

377 Irish Astronomical Journal, 1952, Meteor craters in France: Irish Astron. Jour., v. 2, p. 53–54.

378 Janssen, C. L., 1951, The meteor craters in Hérault, France: Royal Astron. Soc. Canada Jour., v. 45, p. 190–198.

Janssen, an astronomer, finds it reasonable to ascribe origins of Le Clot and the Faugères crater to fragments from one meteorite. He includes here a translation of the Gèze-Cailleux article previously cited (ref. 375).

Ref.

379 Sternenwelt, 1952, Meteor-Krater in Südfrankeich [Meteor craters in southern France]: Sternenwelt, v. 4, p. 174–178.

380 Urania København, 1951, Meteorkraterne ved Faugères [Meteor craters at Faugères]: Urania København, v. 8, p. 1–5.

HOLLEFORD CRATER, LANARK COUNTY, ONTARIO

(Lat 44°47′ N.; long 76°30′ W. Category 2)

381 Beals, C. S., 1957a, A probable meteorite crater of great age: Sky and Telescope, v. 16, no. 11, p. 526–528.

382 ——— 1957b, Results of drilling operations at the Holleford crater: Astron. Jour., v. 62, no. 1249, p. 137–138.

383 ——— 1960, A probable meteorite crater of Precambrian age at Holleford, Ontario: Ottawa Dominion Observatory Pub., v. 24 no. 6, p. 117–142.

Studies of aerial photographs and seismic and diamond-drill data indicate a circular depression with a depth and profile close to those predicted for a meteorite crater of the observed diameter. Below the Paleozoic sediments which fill the crater are several hundred feet of shattered, pulverized rock for which the only adequate explanation is meteorite impact and explosion. The crater is dated at about 500,000,000 years.

384 Beals, C. S., Ferguson, G. M., and Landau, A., 1956, The Holleford crater in Ontario: Sky and Telescope, v. 15, no. 7, p. 296.

Discovery of the New Quebec Crater stimulated Canadian interest in searching aerial photos for other craters in the Canadian Shield. This reports finding the Holleford Crater and preliminary reasons for suspecting its meteoritic origin.

See ref. 129.

Nonmeteoric subsurface materials from the Barringer and Holleford Craters are compared.

385 Bunch, T. E., and Cohen, A. J., 1962, Precambrian coesite [abs.]: Jour. Geophys. Research, v. 67, no. 4, p. 1630–1631.

Coesite discovered in selected drill-core material from the Holleford Crater constitutes the oldest known coesite.

386 ——— 1963, Coesite and shocked quartz from Holleford Crater, Ontario, Canada: Science, v. 142, no. 3590, p. 379–381.

387 Dawson, K. R., 1961, The origin of the Holleford crater breccia: Canadian Mineralogist, v. 6, pt. 5, p. 634–646.

Results of petrographic and geochemical study of three drill cores from the Holleford Crater show no meteoritic material was found; however, results do not refute the meteoritic impact theory.

Ref.
388 Sky and Telescope, 1959, Shattered rocks beneath meteorite craters compared: Sky and Telescope, v. 19, no. 2, p. 94.

See also refs. 7, 14, 64.

HOWELL STRUCTURE, LINCOLN COUNTY, TENN.

(Lat 35°15′ N.; long 86°35′ W. Category 4)

389 Born, K. E., and Wilson, C. W., Jr., 1939, The Howell structure, Lincoln County, Tennessee: Jour. Geology, v. 47, no. 4, p. 371–388.

In their summary of events in the Howell area, the authors include "an explosion, blowing out a crater at least 100 feet in depth and 1 mile in diameter, and piling up limestone debris around the crater." The Howell structure is identified as an example of the cryptovolcanic structures. (*See* ref. 20.)

HUNGARIAN PLAIN, HUNGARY-ROMANIA

(Lat 47° N.; long 21° E. Category 5)

390 Kaljuvee, J., 1933, Die Grossprobleme der Geologie [Major problems in geology]: Tallinn, Estonia, F. Wassermann, 162 p.

The author suggests that the Hungarian Plain is a huge meteorite crater, rimmed by the Transylvanian Alps.

See also ref. 89.

ILUMETSA CRATERS, ESTONIA

(Lat 57°58′ N.; long 27°23′ E. Three craters. Category 6)

391 Aaloe, A. A., 1960, Ilumetsaskie krater' Estonskoi SSR [The Ilumetsa Craters, Estonia]: Meteoritika, no. 18, p. 26–31.

Three depressions, the largest 50 meters in diameter, are discussed. Extensive explorations disclosed no meteoritic material but small magnetic anomalies. Volcanic origin is discounted.

See also ref. 397.

INDIAN MOUND, TENN.

(*See* Wells Creek area)

JEPTHA KNOB STRUCTURE, SHELBY COUNTY, KY.

(Lat 38°06′ N.; long 85°06′ W. Category 4)

392 Bucher, W. H., 1925, Geology of Jeptha Knob: Kentucky Geol. Survey, ser. 6, v. 21, p. 193–237.

"The purpose of this report is to give a detailed description of the stratigraphy, structure, and topography of the Knob and by the observations to test these conclusions of Limney." Limney (ref. 393) had described the disturbed nature of the area.

393 Limney, W. M., 1889?, Reports on the geology of Henry, Shelby, and Oldham Counties: Frankfort, Kentucky Geol. Survey, 70 p.

See also ref. 20.

KA-IMU-HOKU, LANAI, HAWAII

(Lat 20°55′ N.; long 156°53′ W. Category 6)

Ref.

394 Buddhue, J. D., 1947, A possible meteorite crater in the Hawaiian Islands: Pop. Astronomy, v. 55, p. 553; reprinted in Meteorit. Soc. Contr., v. 4, no. 1, p. 82.

K. P. Emory wrote in 1924 of a "pit in the sand" on the Island of Lanai called Ka-imu-hoku or "the place where a meteor fell."

KAALIJÄRV CRATERS, SAAREMA ISLAND, ESTONIA

(Alternate name: Ösel Craters. Lat 58°24′ N.; long 22°40′ E. Seven craters. Category 1)

395 Aaloe, A. A., 1958a, Kaalijärve meteoriidikraatri nr. 5 uurimisest 1955 aastal [Investigation of meteorite crater no. 5 of the Kaalijärv group in 1955]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 2, p. 105–117.

396 ——— 1958b, Novye dannye o meteoritiykh kraterakh na ostrove Saarema [New data on the meteorite craters on the Island of Saarema, Estonian SSR]: Meteoritika, no. 16, p. 108–114.

Aaloe continues a line of investigation initiated by Reinwald and Krinov. In two articles listed here, he reports on partial excavation of crater no. 5.

397 ——— 1963a, Novyye dannyye o stroyenii Ilumetsaskikh kraterov [New data on the structure of the Ilumetsa Craters]: Akad. Nauk Eston, SSR Inst. Geologii Trudy, no. 11, p. 35–43 [with Estonian and English summaries].

398 ——— 1963b, Ob istorii izucheniya Kaaliskikh meteoritnykh kraterov [On the history of the study of the Kaali meteorite craters]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 11, p. 25–34. [with Estonian and English summaries].

399 Alksnis, A., 1961, Meteoritu krāteri Sāremas salā [Meteorite crater on Saarema Island]: Zvaigznota Debess, 1961, p. 4–11.

400 Bronshten, V. A., 1962, Ob obstoyatelstvakh padeniya Kaaliyarvskogo meteorita [Circumstances of the fall of the Kaalijärv meteorite]: Meteoritika, no. 22, p. 42–46.

401 Bronshten, V. A., and Stanyukovich, K. P., 1963, O krateroobrazuyushchikh meteoritakh [On the crater-forming meteorites]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 11, p. 73–83. [with Estonian and English summaries].

402 Fisher, Clyde, 1936, The meteor craters in Estonia: Nat. History, v. 38, no. 4, p. 292–299.

403 ——— 1938, The Estonian meteor craters: Am. Astron. Soc. Pub., v. 9, p. 120–121.

Ref.
404 Giere, W., 1934, Der Meteoritenkrater von Sall auf Oesel [The Sall meteorite crater on Ösel]: Petermanns Mitt., v. 80, p. 372.

405 Kranz, Walter, 1937, "Krater von Sall" auf Ösel, wahrscheinlich "Meteorkrater" [Sall Crater, on Ösel, a probable meteor crater]: Gerlands Beitr. Geophysik, v. 51, no. 1, p. 50–55.

406 Kraus, E., Meyer, R., and Wegener, Alfred, 1928, Untersuchungen uber den Krater von Sall auf Ösel [Investigations of the Sall Crater on Ösel]: Beitr. Geophysik, v. 20, p. 312–378, 428–429.

407 Krinov, E. L., 1945, Meteorite craters on the island of Oesel: Akad. Nauk SSSR Izv., ser. geog. i geofiz., v. 9, no. 4, p. 409–414 [in Russian, with English summary].

408 ——— 1960a, The Kaalijärv craters: Priroda, v. 49, no. 7, p. 55–60 [in Russian].

409 ——— 1960b, Die meteoritischen Krater Kaalijärv auf der Insel Saarema, Estnische SSR [The Kaalijärv meteorite crater on the island of Saarema, Estonia]: Chemie der Erde, v. 20, no. 4, p. 199–216.

410 ——— 1961, The Kaalijärv meteorite craters on Saarema Island, Estonian SSR: Am. Jour. Sci., v. 259, no. 6, p. 430–440.

This group of seven craters was investigated in some detail, morphologically and as to content of meteoritic fragments. The largest crater is believed due to an explosion which destroyed the meteorite; the small craters, which contain meteoritic fragments, are to be considered impact craters from members of the same meteorite shower.

411 Kulik, L. A., 1940, The meteorite crater Kaalijärv in USSR: Priroda, v. 29, no. 2, p. 63–65 [in Russian].

412 La Nature, 1960, Les seuls cratères de météorite connus en Europe [The only known meteorite craters in Europe]: Nature [Paris], v. 88, p. 503.

413 Pobul, E., 1958, Kaalijärve meteoriidikraatri, nr. 3 [The Kaalijärv meteorite crater, no. 3]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, No. 2, p. 119–132.

414 ——— 1963, Primeneniye geofizicheskikh metodov pri issledovanii meteoritnykh kraterov Estonskoy SSR [The use of geophysical methods in the investigation of meteorite craters in the Estonian SSR]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 11, p. 45–51 [with Estonian and English summaries].

415 Pokrovskiy, G. I., 1963, O raschete parametrov meteorita po obrazovannoy im voronke [On the calculation of the parameters of a meteorite from the crater formed by it]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 11, p. 61–71 [with Estonian and English summaries].

Ref.
416 Reinwald, I. A., 1933, Kaali järv—The meteorite craters on the island of Oesel, Estonia: Tartu Univ., Lood. Seltsi, Aruand., v. 39, no. 3–4, p. 183–202; also, Tartu Univ., Geol.-Inst. Toimetused, no. 30, 20 p.

In the references given here, Reinwald details his researches on the Kaalijärv Craters between 1928 and 1941. In this paper he describes the craters and explains their formation by comparison with similar craters in the United States and Australia.

417 ——— 1938, Der Krater von Sall (Kaali järv), ein Meteorkrater-Feld in Estland [The Sall Crater (Kaalijärv), a meteor crater field in Estonia]: Natur und Volk, v. 68, no. 1, p. 16–24.

418 ——— 1940, The Kaalijärv meteor craters (Estonia)—supplementary research of 1937—discovery of meteoric iron: Tartu Univ., Lood. Seltsi, Aruand., v. 45, no. 1–4, p. 81–99; 1939, Tartu Univ., Geol.-Inst. Toimetused, no. 55, 19 p.

419 Reinwald, I. A., and Luha, A., 1928, Bericht uber geologische Untersuchungen am Kaalijärv (Krater von Sall) auf Ösel [Comment on geological investigation of Kaalijärv (Sall Crater on Ösel)]: Tartu Univ., Geol.-Inst. Toimetused, no. 11, p. 30–42.

420 Spencer, L. J., 1938, The Kaalijärv meteorite from the Estonian craters: Mineralog. Mag. [London], v. 25, no. 161, p. 75–80.

421 Treuman, Kh. M., 1963, Dva risunka Kalliskikh meteoritnykh kraterov [Two pictures of the Kaali meteor craters]: Akad. Nauk Eston. SSR Inst. Geologii Trudy, no. 11, p. 85–89. [with Estonian and English summaries].

See also refs. 73, 100.

KALKKOP STRUCTURE, SOUTH AFRICA

(Lat 32°30′ S.; long 24°35′ E. Category 6)

422 Blignaut, J. J. G., Rossouw, P. J., Villiers, J. de, and Russell, H. D., 1948, Kalkkop, *in* The geology of the Schoorsteenberg area, Cape Province: South Africa Dept. Mines Expl. of Sheet no. 166, p. 17–22.

KEELEY LAKE, SASKATCHEWAN

(Lat 54°54′ N.; long 108°08′ W. Category 6)

See ref. 14.

No real investigation of this feature had yet been done. The diameter of Keeley Lake is given as 8 miles.

KENTLAND STRUCTURE, NEWTON COUNTY, IND.

(Lat 40°45′ N.; long 87°25′ W. Category 4)

423 Cohen, A. J., Reid, A. M., and Bunch, T. E., 1962, Central uplifts of terrestrial and lunar craters, 1—Kentland and Serpent Mound structures [abs.]: Jour. Geophys. Research, v. 67, no. 4, p. 1632–1633.

Discovery of trace amounts of coesite in the St. Peter sandstone of the Kentland structure is cited as evidence of impact origin.

Ref.
424 Dietz, R. S., 1947, Meteorite impact suggested by the orientation of shattercones at the Kentland, Indiana, disturbance: Science, v. 105, no. 2715, p. 42–43.

The author speculates on the arrangement of shatter cones as an indication of Kentland as a "root" structure of the crater, formed after the late Paleozoic and eroded before the Pleistocene.

425 Gutschick, R. C., 1961, The Kentland structural anomaly, Indiana, *in* Geology from Chicago to Cincinnati: Geol. Soc. America Guidebook for field trips, 1961, no. 2, p. 12–17.

426 Shrock, R. R., and Malott, C. A., 1933, The Kentland area of disturbed Ordovician rocks in northwestern Indiana: Jour. Geology, v. 41, no. 4, p. 337–370.

The only known area in Indiana exhibiting intense crustal deformation, covers less than 1 square mile and is believed to result from "cryptovolcanic" activity.
See also ref. 20.

KILMICHAEL STRUCTURE, MONTGOMERY COUNTY, MISS.

(Lat 33°30′ N.; long 89°33′ W. Category 4)

427 Butler, M. D., 1962, The meteor crater in Mississippi: Mississippi Acad. Sci. Proc., v. 8, p. 51–52.

428 Priddy, R. R., 1946, Kilmichael dome, an unusual uplift in north-central Mississippi [abs.]: Geol. Soc. America Bull., v. 57, no. 12, pt. 2, p. 1273.

429 Priddy, R. R., and McCutcheon, T. E., 1943, Montgomery County mineral resources: Mississippi Geol. Survey Bull. 51, 116 p.

KÖFELS SITE, ÖTZTAL, AUSTRIA

(Lat 47°13′ N.; long 10°58′ E. Category 6)

430 Ampferer, Otto, 1939, Die geologischen Hypothesen über die Formung des Talraumes zwischen Umhausen und Langenfeld in Ötztale [Geologic hypotheses on the formation of the valley between Umhausen and Langenfeld in Ötztal]: Akad. Wiss. Wien, Math.-naturw. Kl., Sitzungsber., Abt. 1, v. 148, p. 123–140.

431 Ascher, Hans, 1952, Neuer Sachbestand und neue Erkenntnisse über das Bergsturzgebiet von Köfels [New data and new understanding of the landslide area of Köfels]: Geologie and Bauwesen, v. 19, no. 2, p. 128–134.

432 Hammer, Wilhelm, 1937a, Nachtrag zur Kritik der Suesschen Meteorkraterdeutung von Köfels in Nr. 9–10 der "Verhandlungen" [Supplementary note to the critique of the Suess meteor crater interpretation of the Köfels in no. 9–10 of the "Verhandlungen"]: Austria Geol. Bund. Verh., no. 12, p. 268–269.

Ref.

433 Hammer, Wilhelm, 1937b, Ueber einen neuen Versuch zur Lösung des Köfelser Problems [On a new attempt at solution of the Köfels problem]: Austria Geol. Bund. Verh., no. 9–10, p. 195–206.

434 Heissel, Warner, and Ladurner, Otto, 1959, Funde von Gesteinsgläsern in Tirol [Finds of rock glasses in Tyrol], *in* Janetschek, H., ed., De Natura Tiroliensi (Prenn-Festschrift), II: Innsbruck, p. 46–53.

435 Kranz, Walter, 1939, Beitrag zum Köfels-Problem—Die Bergsturz-Hebungs- und Sprengtheorie [A contribution to the Köfels problem—the landslide, uplift and fracture theory]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Beilage-Band 80, Abt. B., p. 113–138.

436 Milton, D. J., 1964, Fused rock from Köfels, Tyrol: Tschermaks Mineralog. Petrog. Mitt., ser. 3, v. 9, no. 1–2, p. 86–94.

Quartz grains are partially melted but not dissolved in the matrix glass. The structure at Köfels is compared to a crater produced by a nuclear device detonated under a steep hillside.

437 Schmidt, Walter, 1937, Bemerkung zur Arbeit von F. E. Suess, Der Meteorkrater von Köfels bei Umhausen in Ötztale, Tirol [Remarks on the work of F. E. Suess, The Köfels meteor crater near Umhausen in Ötztal, Tyrol]: Zentralbl. Mineralogie, v. 2, no. 5, p. 221–222.

438 Senarclens-Grancy, Walter, 1956, Zur Glazialgeologie des Oetztales und seiner Umgebung [Glacial geology of the Ötztal and vicinity]: Geol. Gesell. Wien Mitt., v. 49, p. 256–313.

The author dates the Köfels event as about 8150 B.C., on the basis of glacial chronology.

439 Stutzer, Otto, 1936, Die Talweitung von Köfels im Ötztal (Tirol) als Meteorkrater [The Köfels valley in Ötztal (Tyrol) as a meteor crater]: Deutsche Geol. Gesell. Zeitschr., v. 88, p. 523–525.

440 Suess, F. E., 1936a, Zur Deutung des "Bimssteinvorkommens" von Köfels im Ötztale [On the significance of "pumice occurrence" at Köfels in Ötztal]: Akad. Wiss. Wien, Math.-naturw. Kl., Anz., v. 73, p. 77–80.

441 ——— 1936b, Der Meteor-Krater von Köfels bei Umhausen im Ötztale, Tirol [The Köfels meteor crater near Umhausen in Ötztal, Tyrol]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Beilage-Band 72, Abt. A., p. 98–155.

This is a detailed exposition of the impact crater hypothesis for Köfels.

LABRADOR CRATER, LABRADOR

(*See* Merewether Crater)

LAC COUTURE, QUEBEC

(Lat 60°08′ N.; long 75°20′ W. Category 6)

Ref.

442 Beals, C. S., Dence, M. R., and Cohen, A. J., 1964, Evidence suggesting a meteorite origin for Lac Couture, Quebec [abs.]: Astron. Jour., v. 69, no. 2, p. 134.

"The evidence as a whole suggests an ancient and eroded meteorite crater of approximately 12 km diameter, of which the circular fringe of islands and peninsulas represents the remains of the rim, formerly several hundred meters in height."

LAKE BOSUMTWI, GHANA

(Alternate name: Ashanti Crater. Lat 6°32′ N.; long 1°23′ W. Category 2)

443 Bampo, S. O., 1963, Kumasi conference on the Lake Bosumtwi crater: Nature, v. 198, no. 4886, p. 1150–1151.

This reports a meeting of the West African Science Association in which the Bosumtwi was the central theme.

444 Gentner, W., Lippolt, H. J., and Muller, O., 1964, Das Kalium-Argon-Alter des Bosumtwi-Kraters in Ghana und die chemische Beschaffenheit seiner Glaser [The potassium-argon age of the Bosumtwi Crater in Ghana and the chemical composition of its glasses]: Zeitschr. Naturforschung, v. 19a, no. 1, p. 150–153.

Potassium-argon dating of two glasses gives an average value of 1.3±0.3 million years for the crater, suggesting a common origin with the Ivory Coast tektites and an analogy with an earlier proposal for an impact origin of the Ries Crater and moldavites.

445 Goresy, Ahmed El, 1964, Die Erzmineralien in den Ries- und Bosumtwi-Krater-Gläsen und ihre genetische Deutung [Ore mineralogy of the Ries- and Bosumtwi-crater glasses and their genetic interpretation]: Geochim. et Cosmochim. Acta, v. 28, no. 12, p. 1881–1891.

446 Junner, N. R., 1933, Lake Bosumtwi: Gold Coast Geol. Survey Rept. 1932–1933, p. 4–7.

447 ——— 1934, Lake Bosumtwi: Gold Coast Geol. Survey Rept. 1933–1934, p. 2–6.

448 ——— 1937, The geology of the Bosumtwi caldera and surrounding country: Gold Coast Geol. Survey Bull. no. 8, p. 5–38.

449 Kitson, A. E., 1916, The Gold Coast—Some considerations of its structure, people, and natural history: Geog. Jour. [London], v. 48, no. 5, p. 378.

450 Littler, Janet, Fahey, J. J., Dietz, R. S., and Chao, E. C. T., 1962, Coesite from the Lake Bosumtwi crater, Ashanti, Ghana, *in* Astrogeologic studies semiannual progress report, February 26, 1961, to August 24,

Ref.

1961: U.S. Geol. Survey open-file rept., p. 79–86; abs. in Geol. Soc. America Spec. Paper 68, p. 218.

The fourth natural occurrence of coesite was found in a sample of breccia taken from the crater by N. R. Junner. In the first article, the authors give X-ray diffraction data and make a case for impact origin.

451 Maclaren, Malcolm, 1931, Lake Bosumtwi, Ashanti: Geog. Jour. [London], v. 78, no. 3, p. 270–276.

The author notes that the only genetic theory which appears to fit all observed facts is origin by meteoritic impact.

452 Rohleder, H. P. T., 1934, Uber den Fund von Vergriesungerscheinungen und Drucksuturen am Kesselrand des kryptovulkanischen Bosumtwi-Sees, Ashanti [On the finding of granulation phenomena and pressure sutures on the basin rim of the cryptovolcanic Lake Bosumtwi, Ashanti]: Zentralbl. Mineralogie Geologie und Paläontologie, Abt. A, no. 10, p. 316–318.

Rohleder reports here the discovery of shatter or "percussion" cones in Precambrian quartzite and compares them to cones from the Steinheim Basin, Germany.

453 Rohleder, H. P. T., 1936, Lake Bosumtwi, Ashanti: Geog. Jour. [London], v. 87, no. 1, p. 51–65.

Rohleder discusses and ascribes the origin of Lake Bosumtwi to volcanic activity; a comparison with the Rieskessel is made.

454 Smit, A. F. J., 1962, The origin of Lake Bosumtwi and some other problematic structures: Ghana Jour. Sci., v. 2, no. 2.

455 ——— 1964, Origin of Lake Bosumtwi (Ghana): Nature, v. 203, no. 4941, p. 179–180.

456 Uhden, Richard, 1933, Das Rätsel des Bosumtwi-Sees [The mystery of Lake Bosumtwi]: Umschau, v. 37, no. 8, p. 136–138.

See also ref. 100.

LAKE DELLEN, SWEDEN

(Lat 61°50′ N.; long 16°45′ E. Category 6)

457 Fredriksson, Kurt, and Wickman, F. E., 1963, Meteoriter [Meteorites]: Svensk Naturvetensk., 1963, p. 121–157.

LAKE EL'GYTKHYN, SIBERIA, U.S.S.R.

(Lat 67°30′ N.; long 172°30′ E. Category 6)

458 Nekrasov, I. A., 1958, Ekspeditsiya na ozero El'gytkhyn [An expedition to Lake El'gytkhyn]: Problemy Severa, no. 1, p. 360–370; 1960, translated in Problems of the North, no. 1, p. 365–376.

459 ——— 1963, O proiskhozhdenii i istorii kotlovini ozera El'gigitgin [On the origin and history of the basin of Lake El'gigitgin]: Akad. Nauk SSSR, Sibirskoe Otdelenie, Inst. Geologii i Geofiziki, Trudy, no. 1, p. 47–59.

Ref.
460 Nekrasov, I. A., and Raudonis, P. A., 1963, Meteor craters: Priroda, 1963, no. 1, p. 102–104 [in Russian]; translated abs. titled "Coesite considered specific indicator of meteor craters": Soviet-bloc Research in Geophysics, Astronomy, and Space, no. 56, p. 36–37; abs. in Magnolia, L. R., 1964, Interplanetary matter, a bibliography—1963 supplement, Redondo Beach, Calif., Space Technology Labs., Inc., Research Bibliography, no. 50, p. 154–155.

On the basis of detailed petrographic investigation, Nekrasov concludes that this structure is of tectonic, rather than meteoritic, origin.

LAKE HJUMELN, SWEDEN

(Lat 57°24′ N.; long 16°12′ E. Category 6)

See ref. 457.

LAKE MICHIKAMAU, LABRADOR

(Lat 54°34′ N.; long 64°27′ W. Category 6)

See ref. 14.

A circular structure about 3½ miles in diameter, with a stratified appearance, may be seen on an aerial photograph of the area.

LAKE MIEN, SWEDEN

(Lat 56°25′ N.; long 14°55′ E. Category 6)

461 Högbom, A. G., 1910, [note]: Geol. Fören. Stockholm Förh., v. 32, no. 1, p. 482–483.

Högbom suggests a comparison between Lake Mien and Meteor Crater.

See also ref. 457.

LAKE SILJAN, DALARNA, SWEDEN

(Lat 60°55′ N.; long 14°50′ E. Category 6)

462 Hedstrom, Herman, 1894, Geologiska notiser från Dalarne [Geological notices from Dalarna]: Geol. Fören. Stockholm Förh., v. 16, no. 6, p. 585–593.

Hedstrom describes dikes of what is apparently pseudotachylite.

463 Thorslund, Per, 1960, Notes on the geology and stratigraphy of Dalarna: Internat. Geol. Cong., 21st, Copenhagen 1960, Guide to Excursions nos. A23 and C18, p. 23–26.

464 Thorslund, Per, and Jaanusson, V., 1960, The Siljan district, road-log: Internat. Geol. Cong., 21st, Copenhagen 1960, Guide to Excursions nos. A23 and C18, p. 27–35.

LE CLOT, FRANCE

(*See* Hérault craters)

LONAR LAKE, INDIA

(Lat. 19°59′ N.; long 76°51′ E. Category 3)

465 Arogyaswany, R. N. P., 1962, The Lonar Lake: Indian Minerals, v. 16, no. 1, p. 9–11.

Ref.
466 Blanford, W. T., 1868, Notes on the route from Poona to Nagpur via Ahmednuggur, Jalna, Loonar, Yeotmahal, Mangali, and Kingunghat: India Geol. Survey Records, v. 1, p. 62.

See ref. 162.

In this famous paper, Gilbert supports a cryptovolcanic interpretation for Lonar, by drawing a comparison with Meteor Crater, Ariz.

467 Lafond, E. C., and Dietz, R. S., 1964, Lonar Crater, India, a meteorite crater?: Meteoritics, v. 2, no. 2, p. 111–116.

"Lonar Crater is probably a meteorite crater on the basis of morphology and structure but the degree of certainty is less than either Ashanti Crater or the New Quebec Crater." A chronology of opinions about Lonar Lake is given.

468 LaTouche, T. H. D., and Christie, W. A. K., 1912, The geology of Lonar Lake: India Geol. Survey Records, v. 41, p. 266–285.

469 Medlicott, H. B., and Blanford, W. T., 1879, A manual of the geology of India, pt. 1: Calcutta, India Geol. Survey, p. 379–380.

MACAMIC LAKE, QUEBEC

(Lat 48°52′ N.; long 79°01′ W. Category 6)

See ref. 10.

MALHA CRATER, SUDAN

(Lat 15°06′ N.; long 26°15′ E. Category 5)

470 Colchester, G. U., 1927, Malha crater, Darfur: Sudan Notes and Records, v. 10, p. 233–235.

471 LaPaz, Lincoln, 1947, Note on a supposed meteorite crater in North Africa: Pop. Astronomy, v. 55, p. 49; reprinted in Meteorit. Soc. Contr., v. 4, no. 1, p. 9–10.

LaPaz answers H. H. Nininger (ref. 472) with the information that Dr. L. J. Spencer has referred to this structure as the "explosion volcanic crater of Malha, Sudan."

472 Nininger, H. H., 1943, A possible new meteorite crater in North Africa: Pop, Astronomy, v. 51, p. 96; reprinted in Meteorit. Soc. Contr., v. 3, no. 2, p. 72.

473 Sandford, K. S., 1935, Geological observations on the northwest frontiers of the Anglo-Egyptian Sudan and the adjoining part of the southern Libyan desert: Geol. Soc. London Quart. Jour., v. 91, pt. 3, p. 323–381.

Sandford points out (p. 360) that the Malha crater is a known volcanic explosion crater.

MANICOUAGAN-MUSHALAGAN LAKES AREA, QUEBEC

(Lat 51°28′ N.; long 68°37′ W. Category 4)

474 Bérard, Jean, 1962, Summary geological investigations in the area bordering Manicouagane and Mouchalagane Lakes, Saguenay County: Quebec Dept. Nat. Resources Prelim. Rept. no. 489, 14 p.

Ref.
475 Hoffleit, Dorrit, 1955, Quebec geological feature explored: Sky and Telescope, v. 14, no. 9, p. 374.

476 Kish, Leslie, 1962, Preliminary report on the Lower Hart-Jaune River area, Saguenay County: Quebec Dept. Nat. Resources Prelim. Rept. no. 486, 9 p.

477 Rose, R. R., 1955, Manicouagan Lake—Mushalagan Lake area, Quebec: Canada Geol. Survey Paper 55–2, map.

Geologic studies of the Manicouagan Lake feature indicate a central mountain of igneous origin in an area largely covered by flat-lying lavas of somewhat different character.

478 Willmore, P. L., 1963, The seismic investigation of the Manicouagan-Mushalagan Lake area in the province of Quebec: Ottawa Dominion Observatory Pub. v. 27, no. 6, p. 325–336.

See also refs. 14, 29.

MANSON STRUCTURE, CALHOUN COUNTY, IOWA

(Lat 42°35′ N.; long 94°31′ W. Category 4)

479 Hoppin, R. A., and Dryden, J. E., 1958, An unusual occurrence of pre-Cambrian crystalline rocks beneath glacial drift near Manson, Iowa: Jour. Geology, v. 66, no. 6, p. 694–699.

MECATINA CRATER, QUEBEC

(Lat 50°50′ N.; long 59°22′ W. Category 6)

See ref. 14.

Mecatina is cited as an example of a crater filled with sediments sufficiently consolidated to retain their identity while the surrounding rock suffered severe erosion. An aerial photograph is included.

MELVILLE ISLAND CRATERS, NORTHWEST TERRITORIES, CANADA

(Lat 76°40′ N.; long 109°00′ W. Two craters. Category 6)

See ref. 339.

MENIHEK LAKE AREA, LABRADOR

(Lat 53°42′ N.; long 66°40′ W. Two craters. Category 6)

See ref. 14.

Aerial photographs reveal two circular structures which exhibit a stratified appearance somewhat similar to the Holleford Crater.

MEREWETHER CRATER, LABRADOR

(Alternate names: Hebron Crater, Labrador Crater, Wetherbee Crater.
Lat 58°02′ N.; long 64°02′ W. Category 6)

480 Gillett, J. M., 1960, The flora of the vicinity of the Merewether Crater, northern Labrador: Canadian Field-Naturalist, v. 74, no. 1, p. 8–27.

See ref. 73 .

Krinov places this structure—under Hebron, its location name—in the list of "probable meteorite craters."

Ref.
481 Meen, V. B., 1957, Merewether Crater—A possible meteor crater: Geol. Assoc. Canada Proc., v. 9, p. 49–67.

Meen compares this crater with other lake-filled depressions in the vicinity and suggests a meteoritic origin, despite an inconclusive magnetometer survey and lack of meteoritic material.

MERRIWELL LAKE, QUEBEC

(Approx lat 58° N.; long 65° W. Category 6)

See ref. 24.

METEOR CRATER, ARIZ.

(*See* Barringer Crater)

MIDDLESBORO BASIN, BELL COUNTY, KY.

(Lat 36°37′ N.; long 83°44′ W. Category 4)

482 Englund, K. J., 1964, Geology of the Middlesboro South quadrangle, Tennessee-Kentucky-Virginia: U.S. Geol. Survey Geol. Quad. Map GQ–301.

483 Englund, K. J., and Roen, J. B., 1963, Origin of the Middlesboro Basin, Kentucky; *in* Short papers in geology, hydrology, and topography: U.S. Geol. Survey Prof. Paper 450–E, p. E20–E22.

Recent geologic mapping, the authors feel, does not substantiate previous theories of a tectonic origin for this basin.

484 Englund, K. J., Roen, J. B., and DeLaney, A. O., 1964, Geology of the Middlesboro North quadrangle, Kentucky; U.S. Geol. Survey Geol. Quad. Map GQ–300.

MONTAGNE NOIRE, FRANCE

(*See* Hérault Craters)

MORASKO CRATERS, POLAND

(Lat 52°29′ N.; long 16°54′ E. Category 6)

485 Pokrzywnicki, J., 1964, Meteoryty Polski, 6—Meteoryt Morasko [Meteorites of Poland, 6—Meteorites of Morasko]: Studia Geol. Polonica, v. 15, p. 49–70; English summary, p. 139–140.

Maps and profiles are given for eight craters; the two largest, about 60 meters in diameter, lie in close association with the find sites of several large iron meteorites.

MOUNT DOREEN CRATER FIELD, NORTHERN TERRITORY, AUSTRALIA

(Lat 23° S.; long 133° E. Category 5)

486 Sangster, R. L., 1957, Another meteorite crater in Australia?: Sky and Telescope, v. 16, no. 9, p. 429.

Included here is an aerial photo of a large crater, located in salt-encrusted claypan, in an almost inaccessible area.

Ref.
487 Sangster, R. L., 1959, Letters: Sky and Telescope, v. 18, no. 8. p. 423.

Sangster reports that H. H. Nininger has seen the Mount Doreen structure from the air and determined that it is not a meteorite crater.

MURGAB CRATERS, TADZHIKSKOY SSR, U.S.S.R.

(Alternate name: Pamir Craters. Lat 38°05′ N.; long 76°16′ E. Two craters. Category 6)

488 Bacharev, A. M., 1952, The Murgab meteorite crater: Astron. Tsirk., no. 122, p. 8–10 [in Russian].

489 ——— 1964, Second expedition to investigate the Murgab meteorite craters in eastern Pamir: Astron. Tsirk, no. 145, p. 21–22 [in Russian].

490 ——— 1956, Vtoraya Murgabskaya ekspeditsiya [The second Murgab expedition]: Meteoritika, no. 14, p. 110–112.

491 Hoffleit, Dorrit, 1952, Murgab meteorite craters: Sky and Telescope, v. 12, no. 1, p. 8.

This review tells of the existence of two craters in the East Pamir highlands, one reported in 1926, one discovered by the expedition described by A. M. Bacharev (ref. 488).

492 Sacharov, S. A., and Bacharev, A. M., 1953, The meteorite crater in eastern Pamir: Akad. Nauk Tadzhik. SSR Doklady, no. 6, p. 3–8 [in Russian].

NASTAPOKA ISLANDS ARC, HUDSON BAY, CANADA

(Lat 57°40′ N.; long 80°02′ W. Category 6)

See ref. 14.

The striking parallel between this feature and Mare Crisium on the Moon is noted. Further investigation is indicated.

NEBIEWALE CRATER, NORTHERN TERRITORY, GHANA

(Lat 10°35′ N.; long 1°40′ W. Category 6)

493 Rohleder, H. P. T., 1937, The Nebiewale caldera, Gold Coast: Geog. Jour. [London], v. 90, no. 6, p. 546–549.

The author suggests that the caldera is of "cryptoplutonic" origin.

NEW MEXICO CRATER, MORA COUNTY, N. MEX.

(Lat 36° N.; long 105° W. Category 6)

494 Heybrock, W., 1950, Der Meteoritenfall von New Mexico im Jahre 1933 [The New Mexico meteor fall of 1933]: Sternenwelt, v. 2, p. 15.

495 Hoffleit, Dorrit, 1949, A possible meteorite crater: Sky and Telescope, v. 8, no. 7, p. 165.

Ref.

496 LaPaz, Lincoln, 1949, A possible meteorite crater in northeastern New Mexico: Pop. Astronomy, v. 57, p. 136–137; reprinted in Meteorit. Soc. Contr., v. 4, no. 3, p. 186–187.

A 30-foot crater was observed and photographed in 1948, during an air search for another meteoritic fall. Specimens taken from the crater are typically from an explosion crater of recent origin.

NEW QUEBEC CRATER, UNGAVA, QUEBEC

(Alternate names: Chubb Crater, Ungava Crater. Lat 61°17′ N.; long 73°40′ W. Category 3)

497 Alter, Dinsmore, 1950, A possible large meteoritic crater in Canada: Griffith Observer, v. 14, no. 10, p. 110–112.

498 Carr, W. K., 1952, Ungava crater from the air: Sky and Telescope, v. 11, no. 3, p. 61–62.

499 Currie, K. L., 1964, Rim structure of the New Quebec crater: Nature, v. 201, no. 4917, p. 385.

500 Currie, K. L., and Dence, M. R., 1963, Rock deformation in the rim of the New Quebec crater, Canada: Nature, v. 198, no. 4875, p. 80.

501 Garstang, R. H., 1954, The Ungava crater: British Astron. Assoc. Jour., v. 64, no. 6, p. 255–256.

502 ——— 1957, The New Quebec crater: British Astron. Assoc. Jour., v. 67, no. 3, p. 116.

503 Griffith Observer, 1950, A possible meteorite crater: Griffith Observer, v. 14, no. 9, p. 105, 107.

504 Hargreaves, J., 1958, The Ungava meteorite crater: British Astron. Assoc. Jour., v. 68, no. 1, p. 33–34.

505 Harrison, J. M., 1954, Ungava (Chubb) Crater and glaciation: Royal Astron. Soc. Canada Jour., v. 48, p. 16–20.

Harrison presents evidence of continental glaciation about the crater, asserting that glaciation has obscured evidence of meteoritic origin; LaPaz and Leonard (ref. 514) maintain further evidence from the crater's interior is necessary.

506 Heide, Fritz, 1952, Ein neuer Meteoritenkrater in Nordkanada? [A new meteorite crater in northern Canada?]: Sterne, v. 28, p. 91–95.

507 Hoffleit, Dorrit, 1950, Huge crater possibly of meteorite origin: Sky and Telescope, v. 9, no. 11, p. 273.

508 ——— 1953, On the origin of Chubb Crater: Royal Astron. Soc. Canada Jour., v. 47, p. 126.

509 ——— 1954, Ungava crater origin: Sky and Telescope, v. 13, no. 7, p. 220.

Ref.
510 Irish Astronomical Journal, 1950, The largest meteor crater: Irish Astron. Jour., v. 1, p. 104.

511 Janssen, C. L., 1957, Nye Meteorkratere [A new meteor crater]: Urania København, v. 14, p. 1–3.

512 Kräusel, Richard, 1952, Vulkan-oder Meteor-Krater? [Volcanic or meteor crater?]: Natur und Volk, v. 82, no. 3, p. 73–76.

513 Kretz, Ralph, 1960, Geological observations in northern New Quebec, 34 and 35 (parts of): Canada Geol. Survey Paper 60–12, 17 p., 1 map.

514 LaPaz, Lincoln, and Leonard, F. C., 1954, Notes on the Ungava crater of Quebec, Canada: Meteoritics, v. 1, no. 2, p. 228–229.
See ref. 505.

515 Leonard, F. C., 1950a, The ECN of the Chubb crater of Quebec, Canada (+737,613): Pop. Astronomy, v. 58, p. 469; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 309–310.

516 ——— 1950b, A recently discovered possible meteorite crater in Quebec, Canada: Pop. Astronomy, v. 58, p. 410–411; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 295–296.

517 Massalskaya, K. P., 1951, A large meteorite crater in northern Canada: Priroda, v. 40, no. 9, p. 41–42 [in Russian].

518 Meen, V. B., 1950, Chubb Crater, Ungava, Quebec: Royal Astron. Soc. Canada Jour., v. 44, no. 5, p. 169–180.

The New Quebec Crater was first sighted and photographed from the air by the U.S. Air Force in 1943; in 1950, a prospector, F. W. Chubb, brought it to the attention of Dr. Meen, Director of the Royal Ontario Museum of Geology and Mineralogy. It was on Meen's 1950 and 1951 expeditions to Ungava, described in the nine references cited here, that most of the early data regarding the feature was secured.

519 ——— 1951a, The Canadian meteor crater: Sci. Am., v. 184, no. 5, p. 64–69.

520 ——— 1951b, Chubb Crater, Ungava, Quebec: Geol. Assoc. Canada Proc., v. 4, p. 49–59.

521 ——— 1951c, Chubb Krateret, Ungava, Quebec [Chubb Crater]: Urania København, v. 8, p. 49–58.

522 ——— 1952a, Chubb Crater, Toronto, Canada: Earth Sci. Digest, v. 6, no. 1, p. 15–19.

523 ——— 1952b, Solving the riddle of Chubb Crater: Natl. Geog. Mag., v. 101, no. 1, p. 1–32.

524 ——— 1956, The origin of Chubb Crater: Internat. Geog. Cong., 17th, Washington, D.C., 1952, Proc., p. 357–363.

Ref.

525 Meen, V. B., 1957, Chubb crater—A meteor crater: Royal Astron. Soc. Canada Jour., v. 51, p. 137–154.

526 ——— 1963, The mystery of Chubb Crater, *in* Great adventures with National Geographic: Washington, D.C., Natl. Geog. Soc., p. 252–255.

527 Millman, P. M., 1956, A profile study of the New Quebec Crater: Ottawa Dominion Observatory Pub., v. 18, no. 4, p. 61–82.

Millman finds that the New Quebec Crater agrees well with the standard form of explosion craters of comparable size; he feels that this conclusion strengthens the theory of a meteoritic origin.

528 Nature, 1951, Expedition to Chubb crater in northern Canada: Nature, v. 168, no. 4265, p. 145.

529 Noe-Nygaard, A., 1951, Chubb-krateret in Ungava [Chubb crater in Ungava]: Nordisk Astron. Tidsskr., 1951, p. 127–128.

530 Polar Times, 1962, Meteoritic origin is seen for craters: Polar Times, no. 55, p. 22.

531 Royal Astronomical Society of Canada, 1951, Chubb crater, Ungava: Royal Astron. Soc. Canada Jour., v. 45, p. 93.

532 ——— 1954, Chubb crater, Ungava: Royal Astron. Soc. Canada Jour., v. 46, p. 27–28.

533 Shoemaker, E. M., 1962a, Exploration of the Moon's surface: Am. Scientist, v. 50, no. 1, p. 99–130.

534 ——— 1962b, Geological reconnaissance of the New Quebec Crater, Canada, *in* Astrogeologic studies semiannual progress report, February 26, 1961, to August 24, 1961: U.S. Geol. Survey open-file rept., p. 74–78.

535 Tandberg-Hanssen, Einar, 1952, Chubb-krateret, verdens største meteoritt-krater [Chubb Crater, world's largest meteorite crater]: Naturen, v. 76, p. 98–104.

536 Vega, 1954, Ungava crater and glaciation: Vega, no. 16/17, p. 70.

See also refs. 6, 29, 65, 73, 181, 374, 505.

ODESSA CRATERS, ECTOR COUNTY, TEX.

(Lat 31°48′ N.; long 102°30′ W. Two craters. Category 1)

537 Barringer, D. M., Jr., 1928, A new meteor crater: Acad. Nat. Sci. Philadelphia Proc., v. 80, p. 307–311.

Arthur B. Bibbins discovered a siderite weighing several pounds near Odessa in 1921. Prompted by a further letter from Bibbins (ref. 540) Barringer investigated; here he likens the Odessa Crater to the Meteor Crater of Arizona.

Ref.
538 Barringer, D. M., Jr., 1930, Ein neuer Meteorkrater [A new meteor crater]: Weltall, v. 29, p. 54–56.

This is a translation of ref. 537.

539 Beck, C. W., and LaPaz, Lincoln, 1951, The Odessa, Texas, siderite (ECN=1025, 318): Pop. Astronomy, v. 59, p. 145–151; reprinted in Meteorit. Soc. Contr., v. 5, no. 1, p. 27–33.

540 Bibbins, A. B., 1926, A small meteor crater in Texas: Eng. Mining Jour.-Press, v. 121, no. 23, p. 932.

541 Boon, J. D., and Albritton, C. C., Jr., 1939, Possibility of an additional meteorite crater near Odessa, Texas: Field and Laboratory, v. 8, no. 1, p. 11–17.

542 Evans, G. L., 1941, Ector County unit, *in* Final report covering the period from March 4, 1939, to Sept. 30, 1941, for the state-wide paleontologic-mineralogic survey in Texas: Austin, Texas Univ. Bur. Econ. Geology, p. 30–34.

543 ——— 1961, Investigations at the Odessa meteor craters, *in* Proceedings of the Geophysical Laboratory/Lawrence Radiation Laboratory Cratering Symposium, Washington, D.C., March 28–29, 1961: California Univ., Livermore, Lawrence Radiation Lab. Rept. UCRL-6438, pt. 1, paper D, 11 p. (Report prepared for U.S. Atomic Energy Commission.)

Evans presents some new maps of the Odessa Craters, along with a history of investigations and new data obtained in 1958 and 1960 drillings.

544 Lord, J. O., 1941, Metal structures in Odessa, Texas, and Canyon Diablo, Arizona, meteorites: Pop. Astronomy, v. 49, p. 493–500.

545 Merrill, G. P., 1922, Meteoritic iron from Odessa, Ector Co., Texas: Am. Jour. Sci., 5th ser., v. 3, no. 17, p. 335–337.

546 Monnig, O. E., 1935, The Odessa, Texas, meteorite crater: Pop. Astronomy, v. 43, p. 34–37; 1936, reprinted in Soc. Research on Meteorites Contr., fascicule 1, p. 1–4.

547 Nininger, H. H., 1934, The Odessa, Texas, meteorite crater: Pop. Astronomy, v. 42, p. 46–47.

Nininger voices his conviction that Odessa is a meteorite crater. He mentions magnetometer tests which indicate a sizeable magnetic material buried at about 400 feet.

548 Roach, C. H., Johnson, G. R., McGrath, J. G., Merritt, V. M., and Sterrett, T. S., 1963, Thermoluminescence investigations at the Odessa meteorite craters, Texas, *in* Astrogeologic studies annual progress report, August 25, 1961, to August 24, 1962: U.S. Geol. Survey open-file rept., pt. B, p. 107–117.

Ref.
549 Sellards, E. H., 1927, Unusual structural features in the plains region of Texas [abs.] : Geol. Soc. America Bull., v. 38, no. 1, p. 149.

This abstract is the first description of the Odessa structure.

550 ——— 1940, Odessa meteor crater [abs.] : Geol. Soc. America Bull., v. 51, no. 12, pt. 2, p. 1944.

551 ——— 1941, Odessa meteor craters [abs.] : Geol. Soc. America Bull., v. 52, no. 12, pt. 2, p. 2007.

552 Sellards, E. H., and Barnes, V. E., 1940, Meteor crater of Ector County, Texas: Geol. Soc. America 53d Ann. Mtg. Excursions, p. 129–130.

553 ——— 1943, Progress in excavating the Odessa, Texas, meteorite crater [abs.] : Pop. Astronomy, v. 51, p. 224–225 ; reprinted in Soc. Research on Meteorites Contr., v. 3, no. 2, p. 83.

554 Sellards, E. H., and Evans, G. L., 1941, Statement of progress of investigation at Odessa meteor craters: Austin, Texas Univ. Bur. Econ. Geology, 12 p., addenda on p. 13.

Sellards and Evans were participants in a University of Texas expedition to Odessa between 1929 and 1941. Mapping, sampling, core drilling, and extensive excavations resulted in the discovery of numerous meteorites and several small craters.

See also refs. 73, 365.

ÖSEL CRATERS, ESTONIA

(*See* Kaalijärv Craters)

PAMIR CRATERS, U.S.S.R.

(*See* Murgab Craters)

PANAMINT CRATER, INYO COUNTY, CALIF.

(Lat 36°05′ N.; long 117°22′ W. Category 5)

555 Dietz, R. S., and Buffington, E. C., 1964, Panamint crater, California—Not meteoritic: Meteoritics, v. 2, no. 2, p. 179–181.

This crater is likely a collapse pit. Results of a more intensive investigation by L. E. Humiston and colleagues of the Naval Ordnance Test Station are forthcoming.

PARIS (SUCY-EN-BRIE AND ALENTOURS) LAKES, FRANCE

(Lat 48°56′ N.; long 2°30′ E. Category 6)

See ref. 3.

PARRY SOUND CRATER, ONTARIO

(Lat 45°22′ N.; long 79°55′ W. Category 6)

Ref.

556 McKean, F. K., 1964, A meteoritic crater in the Pre-Cambrian Shield: Meteoritics, v. 2, no. 3, p. 243–248.

Some evidence for the meteoritic origin of this feature, 1.5 miles in diameter, is given.

See also ref. 3.

PATOMSKII CRATER, IRKUTSK OBLAST, U.S.S.R.

(Lat 55°00′ N.; long 116°58′ E. Category 6)

557 Portnov, A. M., 1962, Krater na Patomskom nagore [A crater on the Patom Plateau]: Priroda, 1962, no. 11, p. 102–103; abs. in Magnolia, L. R., 1963, Interplanetary matter, a bibliography—1962 supplement, Redondo Beach, Calif., Space Technology Labs., Inc., Research Bibliog. no. 46, p. 157.

It is postulated that this crater was formed 150–200 years ago. The presence of a raised rim and a central hillock composed of fragmented bedrock are cited as evidence of explosive origin.

558 ——— 1964, O kratere na Patomskom nagor'ye [On the crater on the Patom plateau]: Meteoritika, no. 25, p. 194–197.

The crater, 86 meters in diameter, is described as having a ring wall and central hill and shattered but not altered rocks.

PILOT LAKE, NORTHWEST TERRITORIES, CANADA

(Lat 60°19′ N.; long 111°01′ W. Category 6)

See ref. 24.

PRETORIA SALT PAN, SOUTH AFRICA

(Lat 25°30′ S.; long 28°00′ E. Category 3)

559 Rohleder, H. P. T., 1933, The Steinheim basin and the Pretoria Salt Pan—Volcanic or meteoric origin?: Geol. Mag. [London], v. 70, no. 833, p. 489–498.

The outstanding features of the Salt Pan are the circular depression and shattered rocks on the bottom of the depression and in the vicinity. Nothing suggests volcanic origin, but the parallelism with a meteor crater is obvious.

560 Wagner, P. A., 1922, The Pretoria Salt-pan—A soda caldera: South Africa Geol. Survey Mem. 20, 136 p.

RICHÂT CRATER, MAURITANIA

(Lat 21°09′ N.; long 11°24′ W. Category 2)

561 Cailleux, André, Guillemaut, Armel, and Pomerol, Charles, 1964, Présence de coésite, indice de hautes pressions, dans l'accident circulaire des Richât (Adrar Mauritanien) [Presence of coesite, index of high pressures, in the circular irregularity of the Richât (Mauritanian Adrar)]: Acad. Sci. [Paris] Comptes Rendus, v. 258, no. 22, p. 5488–5490.

Ref.
562 Richard-Molard, Jacques, 1948, La boutonnière du Richât en Adrar Mauritanien [The Richât buttonhole at Adrar, Mauritania]: Acad. Sci. [Paris] Comptes Rendus, v. 227, p. 142–143.

The author considers the Richât "buttonhole" to be the result of a laccolithic thrust.

563 ——— 1952, La pseudo-boutonnière du Richât [The Richât pseudobuttonhole]: French West Africa Dir. Mines Bull., no. 15, p. 391–401.

See also ref. 113.

RIESKESSEL, BAVARIA, GERMANY

(Lat 48°53′ N.; long 10°37′ E. Category 2)

564 Ackermann, W., 1958, Geologisch-petrographische Untersuchungen im Ries [Geologic-petrographic investigations in the Ries]: Geol. Jahrb., v. 75, p. 135–182.

565 Ahrens, Wilhelm, 1929a, Geophysikalische Probleme des Rieses [Geophysical problems of the Ries]: Deutsche Geol. Gesell. Zeitschr., v. 81, p. 99–109.

566 ——— 1929b, Die Tuffe des Nördlinger Rieses und ihre Bedeutung für das Gesamtproblem [Tuffs of the Nördlingen Ries and their bearing on the whole problem]: Deutsche Geol. Gesell. Zeitschr., v. 81, p. 94–99.

567 Bentz, Alfred, 1925, Die Entstehung der "Bunter Breccie", das zentral Problem im Nördlinger Ries und Steinheimer Becken [Origin of "bunter breccia", the central problem in the Nördlingen Ries and the Steinheim Basin]: Zentralbl. Mineralogie, Abt. B, p. 97–104, 141–145.

568 ——— 1927, Geologische Beobachtungen am westlichen Riesrand [Geological study of the western rim of the Ries]: Deutsche Geol. Gesell. Zeitschr., v. 79, p. 405–438.

569 ——— 1928, Das Nördlinger Riesproblem und seine Deutungen: [The problem of the Nördlingen Ries and its interpretation]: Preuss. Geol. Landesanstalt und Bergakad. Sitzungsber., no. 3, p. 72–86.

570 Branco, Wilhelm, 1902, Das vulkanische Vorries und seine Beziehung zum vulkanischen Ries bei Nördlingen [The volcanic Vorries and its relation to the volcanic Ries near Nördlingen]: Akad. Wiss. Berlin, Phys.-math. Kl., Abh. 1, p. 1–132.

571 Chao, E. C. T., and Littler, Janet, 1962, The petrography of impactites and tektites, with special reference to a dense impactite glass from the Ries crater [abs.]: Jour. Geophys. Research, v. 67, no. 9, p. 3548–3549.

572 ——— 1963, Dense glass from the Ries crater of southern Germany, *in* Astrogeologic studies annual progress report, August 25, 1961, to August 24, 1962: U.S. Geol. Survey open-file rept., pt. C, p. 103–114.

Ref.
573 Cotta, Bernhard, 1834, Geognostische Beobachtungen im Riesgau und dessen Umgebungen [Geognostic observations in the Ries and its environs]: Neues Jahrb. Mineralogie Geognosie Geologie und Petrefaktenk., p. 307–318.

574 Dehm, Richard, 1932, Geologische Untersuchungen im Ries—Das Gebiet des Blattes Monheim [Geological study of the Ries—Monheim map area]: Neues Jahrb. Mineralogie Geologie and Paläontologie, Beilage-Band 67, Abt. B, p. 139–256.

575 ——— 1962, Das Nördlinger Ries und der Meteortheorie [The Nördlingen Ries and the meteoritic theory]: Bayerische Staatssamml. Paläont. Hist. Geol. Mitt., v. 2, p. 69–72.

576 Dorn, Cornelius von, 1942, Beitrage zur Geologie des Rieses [Contributions to the geology of the Ries]: Zentralbl. Mineralogie Geologie und Paläontologie, Abt. B, p. 115–116, 145–159, 161–187, 311–328, 329–348.

577 Dorn, Paul 1950, Ein Jahrhundert Riesgeologie [A century of the geology of the Ries]: Deutsche Geol. Gesell. Zeitschr., v. 100, p. 348–365.

This is a concise history and bibliography of the Ries problem to 1948.

578 Engelhardt, Wolf von, and Hörz, Friedrich, 1964, Hochdruckgläser im Nördlinger Ries [High pressure glasses in the Nördlingen Ries]: Naturwissenschaften, v. 51, no. 11, p. 264.

579 Gentner, W., Lippolt, H. J., and Schaeffer, O. A., 1963, Argonbestimmung am Kaliummineralien, XI—Die Kalium-Argon-Alter des Gläser der Nördlinger Rieses und der böhmischmahrischen Tekite [Argon determination on the potassium minerals, 11—The potassium-argon age of the Nördlingen Ries and of the Bohemian-Moravian tektites]: Geochim. et Cosmochim. Acta, v. 27, no. 2, p. 191–200.

On the basis of potassium-argon dates obtained from seven suevite samples from the Ries and six tektites from Czechoslovakia, it is suggested that the tektites may have originated from the explosion that formed the Ries Crater.

580 Gerstlauer, K., 1940, Geologische Untersuchungen im Ries—Das Gebiet des Blattes Offingen [Geological study of the Ries—The Offingen map area]: Bavaria Oberbergamt Geol. Land. Abh. no. 35.

581 Gümbel, C. W., 1870, Uber den Riesvulkan und uber vulkanisch Erscheinungen im Rieskessel [On the Ries Volcano and evidence of volcanism in the Ries Basin]: Akad. Wiss. München Sitzungsber., Abt. 1, p. 153–200.

582 Hölder, H., 1962, Zur Geschichte der Ries-Forschung [History of research on the Ries]: Ver. Vaterl. Naturk. Württemberg Jahresh., v. 117, p. 10–17.

583 Johnson, G. G., Vand, Vladimir, and Dachille, Frank, 1964, Additional rims around the Ries Kessel meteorite crater: Nature, v. 201, no. 4919, p. 592–593.

Ref.

584 Knebel, Walther von, 1902, Beitrage zur Kenntniss der Ueberschiebungen am vulkanischen Ries bei Nördlingen [Study of volcanic phenomena in the Nördlingen Ries]: Deutsche Geol. Gesell. Zeitschr., v. 55, p. 236–295.

585 Kranz, Walter, 1911, Das Nördlinger Riesproblem [The Nördlingen Ries problem]: Oberrheinischer Geol. Ver. Jahresber. und Mitt., new ser., v. 1, p. 32–35.

586 ——— 1912, Das Nördlinger Riesproblem, II [The Nördlingen Ries problem, II]: Oberrheinischer Geol. Ver. Jahresber. und Mitt., new ser., v. 2, p. 54–65.

587 ——— 1928, Vulkanexplosionen, Sprengtechnik, praktische Geologie und Ballistik [Volcanic explosions, blasting practice, practical geology, and ballistics]: Deutsche Geol. Gesell. Zeitschr., v. 80, p. 257–307.

588 ——— 1934, Fünfte Fortsetzung, der Beiträge zum Nöordlinger Riesproblem [Contribution to the Nördlingen Ries problem, part 5]: Zentralbl. Mineralogie, Abt. B., no. 7, p. 262–271.

589 ——— 1937a, Sechste Fortsetzung der Beiträge zum Nördlinger Riesproblem [Contribution to the Nördlingen Ries problem, part 6]: Zentralbl. Mineralogie, Abt. B, no. 5, p. 215–221.

590 ——— 1937b, Steinheimer Becken, Nördlinger Ries und "Meteorkrater" [The Steinheim Basin, Nördlingen Ries and Meteor Crater]: Petermanns Geog. Mitt., v. 83, no. 7/8, p. 198–202.

591 ——— 1945–1948, Siebte Fortsetzung der Beiträge zum Nördlinger Riesproblem [Contribution to the Nördlingen Ries problem, part 7]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Monatsh., Abt. B, no. 9–12, p. 336–361.

592 ——— 1949a, Achte Fortsetzung der Beiträge zum Nördlinger Riesproblem [Contribution to the Nördlingen Ries problem, part 8]: Neues Jahrb. Mineralogie Geologie und Paläontologie. Monatsh., Abt. B, no. 4–6, p. 154–173.

593 ——— 1949b, Zur Geophysik und Geologie des Riesgebietes nach H. Reich, A. Roll und L. Wegele [On the geophysics and geology of the Ries area, by H. Reich, A. Roll, and L. Wegele]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Monatsh., Abt. B, no. 10, p. 289–294.

594 ———1950, Vorkommen, Lagerung, Herkunft und Alter der Vorries-Braunkohlen und ihre Bedeutung für das Riesproblem [Occurrence, deposition, origin, and age of Vorries brown coals and their bearing on the Ries problem]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Monatsh., no. 9, p. 357–374.

595 ——— 1952, Neunte Fortsetzung der Beiträge zum Nördlinger Riesproblem [Contribution to the Nördlingen Ries problem, part 9]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Monatsh., no. 2, p. 49–65.

Ref.

596 Löffler, Richard, 1912, Die Zusammensetzung des Grundgebirges im Ries [Nature of the basement in the Ries]: Ver. Vaterl. Naturk. Württemberg Jahresh., v. 68, p. 107–145.

597 ——— 1925, Beiträge zur Riesentstehungshypothese [Contribution to the hypothesis of the origin of the Ries]: Oberrheinischer Geol. Ver. Jahresber. und Mitt., new ser., v. 14, p. 26–83.

598 ——— 1939, Zum Riesproblem [On the Ries problem]: Ver. Vaterl. Naturk. Württemberg Jahresh., v. 95, p. 127–134.

599 Moos, August, 1925, Die Trümmerhohen im südlichen Vorries und ihre Bedeutung für das Riesproblem [The height of debris in the southern Vorries and its relation to the Ries problem]: Oberrheinischer Geol. Ver. Jahresber. und Mitt., new ser., v. 14, p. 99–147.

600 ——— 1928, Kommen die Trummergesteine—Griese und Bunte Breccien—im südlichen Vorries aus dem Ries? [Does the rubble—gray and colored breccia—in the southern Vorries come from the Ries?]: Zentralbl. Mineralogie, Abt. B, p. 417–428.

601 Nathan, Hans, 1925, Geologische Untersuchungen im Ries—Das Gebiet des Blattes Möttingen [Geological investigation of the Ries—the Möttingen map area]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Beilage-Band 53, Abt. B, p. 31–97.

602 ——— 1935, Geologische Untersuchungen im Ries—Das Gebiet des Blattes Ederheim [Geological study of the Ries—The Ederheim map area]: Bavaria Oberbergamt Geol. Land. Abh., no. 19, 42 p.

603 ——— 1957, Wasserbohrungen im Ries [Water drilling in the Ries]: Geol. Jahrb., v. 74, p. 135–146.

604 Oberdorfer, Richard, 1905, Die vulkanischen Tuffe des Rieses bei Nördlingen [Volcanic tuffs of the Ries near Nördlingen]: Ver. Vaterl. Naturk. Württemberg Jahresh., v. 61, p. 1–40.

605 Preuss, Ekkehard, 1964, Das Ries und die Meteoritentheorie [The Ries and meteoritic theory]: Fortschr. Mineralogie, v. 41, no. 2, p. 271–312.

606 Reich, Hermann, 1929, Geophysikalische Probleme des Rieses [Geophysical problems of the Ries]: Deutsche Geol. Gesell. Zeitschr., v. 81, p. 99–109.

607 Reuter, Lothar, 1925, Die Verbreitung jurasischer Kalkblöcke aus dem Ries in südbayerischen Diluvial-gebiet [Distribution of the Jurassic limestone blocks from the Ries in the southern Bavarian glacial region]: Oberrheinischer Geol. Ver. Jahresber. und Mitt., new ser., v. 14, p. 191–218.

608 Schröder, Jöachim, and Dehm, Richard, 1950, Geologische Untersuchungen im Ries [Geological studies in the Ries]: Naturwiss. Ver. Schwaben und Neuberg (e.v.) Augsburg Abh., no. 5, 147 p.

Ref.

609 Schuster, Mattheus, 1925, Neues zum Problem des Rieses [New data on the Ries problem]: Oberrheinischer Geol. Ver. Jahresber, und Mitt., new ser., v. 14, p. 280–291.

610 Schutte, K., 1927, Das Ergebnis der Schweremessungen im Ries [Result of gravity measurements in the Ries]: Bayerische Akad. Wiss. Sitzungsber., p. 133–144.

611 Seeman, Reinhold, 1939, Versuch einer vorwiegend tektonischen Erklarung des Nördlinger Rieses [Attempt at a predominantly tectonic explanation of the Ries]: Neues Jahrb. Mineralogie Geologie und Paläontologie, Beilage-Band 81, Abt. B, no. 1, p. 70–166; no. 2, p. 169–214.

612 ——— 1943, Das ratselhafte Ries [The enigmatical Ries]: Schwaben, no. 251, 16 p.

613 Seidl, Erich, 1932, Nördlinger Ries, eine typische Zerreib-Zone, entstanden durch tektonische Spannungen der Erdrinde [Nördlingen Ries, a typical fracture zone, caused by tectonic strain of the Earth's crust]: Deutsche Geol. Gesell. Zeitschr., v. 84, p. 18–23.

614 Shoemaker, E. M., and Chao, E. C. T., 1961, New evidence for the impact origin of the Ries Basin, Bavaria, Germany: Jour. Geophys. Research, v. 66, no. 10, p. 3371–3378; also in Proceedings of the Geophysical Laboratory/Lawrence Radiation Laboratory Cratering Symposium, Washington, D.C., March 28–29, 1961, California Univ., Livermore, Lawrence Radiation Lab. Rept. UCRL–6438, pt. 1, paper B, 13 p. (Report prepared for U.S. Atomic Energy Commission.)

See ref. 245.

The author contends that the Ries is a meteorite crater, not a cryptovolcanic structure as believed by many.

615 Treibs, Walter, 1950, Geologische Untersuchungen im Ries—das Gebiet des Blattes Otting [Geological study of the Ries—The Otting map area]: Geol. Bavarica, no. 3, 52 p.

616 Vand, Vladimir, 1963, The meteoritic craters of Ries Kessel and Steinheim Basin and their relation to tektites: Pennsylvania State Univ., Mineral Industries, v. 32, no. 4, p. 1–5, 7.

617 Vand, Vladimir, Dachille, Frank, and Simons, P. Y., 1964, Qualitative dating of glasses, applied to tektite-like objects from the Ries Kessel meteoritic craters: Nature, v. 201, no. 4919, p. 597–598.

618 Wagner, Georg, 1962, Das Ries, kein Meteorkrater [The Ries, not a meteorite crater]: Ver. Vaterl. Naturk, Württemberg Jahresh., v. 117, p. 17–18.

619 Weiskirchner, Walter, 1962, The origin of the Ries: Oberrheinischer Geol. Ver. Jahresber. und Mitt., v. 94, p. 17–30.

Evidence on the origin of the "crater" is reviewed. A meteoritic impact, followed by a period of volcanic activity, is suggested.

Ref.
620 Weltraumfahrt, 1961, Das Nördlinger Ries—Ein Meteorkrater? [Nördlingen Ries—A meteor crater?]: Weltraumfahrt, v. 12, p. 143.

621 Werner, E., 1904, Das Ries in der schwäbisch-fränkischen Alb. [The Ries in the Swabian-Franconian Alb.]: Blätter der Schwäb. Albvereins, v. 16, p. 153–167.

This is about the first suggestion that the Ries is an impact structure.

See also ref. 22.

SAN LUIS MARIA BACA GRANT CRATER, COLO.

(*See* Crestone Crater)

SAULT AU COCHONS STRUCTURE, QUEBEC

(Lat 49°17′ N.; long 70°05′ W. Category 6)

See ref. 14.

Plate 11 illustrates this circular feature, 7 miles in diameter, which to date has been examined only on aerial photographs.

SAYAN CRATER, KHAKAS, U.S.S.R.

(Lat 53°45′ N.; long 93°10′ E. Category 6)

622 Voroshilov, M. V., 1962, Meteoritnyi krater v zapadnom Sayana [Meteoritic crater in western Sayan]: Priroda, 1962, no. 3, p. 107–109; abs. in Magnolia, L. R., 1963, Interplanetary matter, a bibliography, Redondo Beach Calif., Space Technology Labs., Inc., Research Bibliog., no. 42, p. 486.

This elliptical crater, partially lake-filled and overgrown with forest, measures 370–400 meters at the major axis, 250–350 meters at the minor axis.

SEMSIYÂT DOME, MAURITANIA

(Lat 21°01′ N.; long 11°50′ W. Category 5)

See ref. 113.

Monod considers this structure to be, without a doubt, a dome.

SERPENT MOUND STRUCTURE, ADAMS COUNTY, OHIO

(Lat 39°02′ N.; long 83°25′ W. Category 4)

623 Bucher, W. H., 1933, Ueber eine typische kryptovulkanische Störung im sudlichen Ohio [A typical cryptovolcanic disturbance in southern Ohio]: Geol. Rundschau, v. 23A, p. 65–80.

See ref. 423.

Coesite is reported to have been found in the shatter cones of the Lilley Dolomite of the Serpent Mound structure.

See also refs. 20, 27, 36.

SIERRA MADERA STRUCTURE, PECOS COUNTY, TEX.

(Lat 30°36′ N.; long 102°55′ D. Category 4)

Ref.

624 Adkins, W. S., 1927, The geology and mineral resources of the Fort Stockton quadrangle: Texas Univ. Bull. 2738, 166 p., 5 pls.

See ref. no. 18.

On the basis of P. B. King's interpretation (ref. 627), Boon and Albritton suggest an impact origin for the Sierra Madera and Vredefort structures.

625 Eggleton, R. E., and Shoemaker, E. M., 1961, Breccia at Sierra Madera, Texas, *in* Short papers in the geologic and hydraulic sciences: U.S. Geol. Survey Prof. Paper 424–D, p. D151–D153.

The breccia at Sierra Madera is tentatively identified as a great lens, 1½ miles across and possibly as much as 2,800 feet thick; it may have once underlain a crater two miles in diameter.

626 Geyer, R. A., and Van Lopik, J. R., 1963, Reconnaissance geophysical survey of the Sierra Madera, Texas "dome" and its lunar implications [abs.]: Am. Geophys. Union Trans., v. 44, no. 1, p. 76.

627 King, P. B., 1930, The geology of the Glass Mountains, Texas—Pt. 1, Descriptive geology: Texas Univ. Bull. 3038, 167 p.

King compares the Sierra Madera uplift with the Vredefort dome.

628 Shoemaker, E. M., and Eggleton, R. E., 1964, Re-examination of the stratigraphy and structure of Sierra Madera, Texas, *in* Astrogeologic studies annual progress report, August 25, 1962, to July 1, 1963: U.S. Geol. Survey open-file rept., pt. B, p. 98–106.

629 Van Lopik, J. R., and Geyer, R. A., 1963, Gravity and magnetic anomalies of the Sierra Madera, Texas "dome": Science, v. 142, no. 3599, p. 45–47.

"A geographical traverse across the Sierra Madera 'dome' indicates a negative gravity anomaly of 1½ milligals over the zone of brecciation in the center and a residual positive anomaly of ½ milligal associated with a positive anomaly of 25×10^{-5} oersted to the southeast of the zone of brecciation."

630 West Texas Geological Society, 1952, Road logs, Sierra Madera: West Texas Geol. Soc. Guidebook, 1952 Spring field trip—Marathon Basin, Brewster and Pecos Counties, Trans-Pecos Texas, p. 8–11, 44.

631 ——— 1959, Road log to Sierra Madera: West Texas Geol. Soc. Guidebook, Geology of the Val Verde basin and field trip guidebook, 1959, p. 8–11.

See also ref. 36.

SIKHOTE-ALIN CRATERS, U.S.S.R.

(Lat 46°10′ N.; long 134°39′ E. 122 craters. Category 1)

632 Akademiya Nauk SSSR, Komitet po Meteoritam, 1959–1963, Sikhote-Alinskii zheleznyi meteoritnyi dozhd' [Sikhote-Alin iron meteorite shower]: Moscow, Izdat. Akad. Nauk SSSR, 2 vols.

These are the definitive volumes on Sikhote-Alin.

Ref.
633 Astronomie, 1948, La gigantesque météorite de Sihotè-Aline (U.R.S.S.) [The huge Sikhote-Alin meteorite] : Astronomie, v. 62, p. 294–295.

634 Divari, N. B., 1948a, Determination of the path of the Sikhote-Alin meteorite from eyewitness accounts: Astron. Zhur., v. 25, p. 66–73 [in Russian].

635 ——— 1948b, First expedition to the Sikhote-Alin meteorite: Astron. Kalendar' Gorkiy, p. 119–125 [in Russian].

636 ——— 1958, Okonchatel'nye elementy atmosfernoy traektoriy Sichote-Alinskogo meteorita [Final results of establishing the atmosphere trajectory of the Sikhote-Alin meteorite] : Meteoritika, no. 16, 37–38.

637 ——— 1962, Otsenka skorosti padeniya nekotorykh ekzemplyarov Sikhote-Alinskogo meteoritnogo dozhdya [Estimate of the impact velocities of some specimens of the Sikhote-Alin multiple fall] : Meteoritika, no. 22, p. 31–41.

638 Fessenkov, V. G., 1947a, Preliminary results of the Sikhote-Alin meteorite investigations: Akad. Nauk Kazakh. SSR Vestnik, v. 4, no. 3, p. 28–30 [in Russian].

639 ——— 1947b, The Sikhote-Alin meteorite: Astron. Zhur., v. 24, p. 302–317 [in Russian].

640 ——— 1947c, The Sikhote-Alin meteorite crater: Astron. Zhur., v. 24, p. 361–371 [in Russian].

641 ——— 1948, Circumstances of the Sikhote-Alin meteorite fall: Astron. Zhur., v. 25, p. 192–200 [in Russian].

642 ——— 1951, Orbit of the Sikhote-Alin meteorite: Meteoritika, no. 9, p. 27–31 [in Russian].

643 ——— 1955, Sikhote-Alin meteorite, *in* Kaiser, T. R., ed., Meteors (a symposium on meteor physics) : Jour. Atmospheric and Terrestrial Physics, Spec. Supp., no. 2, p. 179–183.

644 ——— 1958, Nekotonye soobrazheniya ob energiy obrazovaniya kraterov i skorosti padeniya Sichote-Alinskogo meteorita [A few thoughts on the energy of crater-formation and the fall velocity of the Sikhote-Alin meteorite] : Meteoritika, no. 16, p. 147–155.

645 Fireman, E. L., 1961, Uranium in the Sikhote-Alin meteorite and its relation to the lead method of age determination: Nature, v. 192, no. 4803, p. 644–645.

646 Fisher, D. E., 1961, Cosmic ray ages of the Treysa and Sikhote-Alin meteorites: Nature, v. 190, no. 4772, p. 225–227.

647 ——— 1963, "Ages" of the Sikhote-Alin iron meteorite: Science, v. 139, no. 3556, p. 752–753.

Ref.

648 Fonton, S. S., 1949, Second expedition to investigate the Sikhote-Alin meteorite fall: Meteoritika, no. 6, p. 13–25 [in Russian].

649 Krinov, E. L., 1947, An iron meteorite: Priroda, v. 36, no. 12, p. 3–13 [in Russian].

650 ——— 1948a, Character of the Sikhote-Alin meteorite shower: Akad. Nauk SSSR Doklady, v. 59, p. 459–462 [in Russian].

651 ——— 1948b, The Sikhote-Alin iron meteorite shower: Astron. Kalendar' Gorkiy 1948, p. 113–118 [in Russian].

652 ——— 1948c, The Sikhote-Alin meteorite shower: Moscow Akad. Nauk SSSR, 64 p. [in Russian].

653 ——— 1949a, On the Sikhote-Alin meteorite shower: Meteoritika, no. 5, p. 14–22 [in Russian].

654 ——— 1949b, Structure of the melted crust of the Sikhote-Alin meteorite: Akad Nauk SSSR Doklady, v. 64, p. 475–478 [in Russian].

655 ——— 1950a, Form and surface structure of the fusion crust of individual specimens of the Sikhote-Alin iron meteoritic rain: Meteoritika, no. 8, p. 78–99 [in Russian].

656 ——— 1950b, Some characteristic features of the Sikhote-Alin (Ussuri) iron-meteorite shower (of the U.S.S.R., ECN=±1347,462): Pop, Astronomy, v. 58, p. 298–302; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 264–269.

657 ——— 1952, Results of four years of field work and study of specimens of the Sikhote-Alin iron meteoritic rain: Meteoritika, no. 10, p. 83–99 [in Russian].

658 ——— 1956a, Der Eisenmeteoritenregen von Sichote-Alin [The Sikhote-Alin iron meteorite shower]: Chemie der Erde, v. 18, no. 1–2, p. 56–87.

659 ——— 1956b, The Siberian meteorite fall of February, 1947: Sky and Telescope, v. 15, no. 7, p. 300–301.

660 ——— 1958a, Obstanovka nadeniya Sichote-Alinskogo zheleznogo meteoritnogo dozhdya [Circumstances of the fall of the Sikhote-Alin meteoritic iron rain]: Meteoritika, no. 16, p. 39–41.

661 ——— 1958b, Some peculiar characteristics of the meteorite fall in Sikhote-Alinsk: Pop. Astronomy, v. 58, p. 129–132.

662 ——— 1960, The Tunguska and Sikhote-Alin meteorites, *in* Principles of meteoritics, translated from the Russian by Irene Vidziunas and edited by Harrison Brown: London, Pergamon Press, p. 12–154.

This chapter relates the Tunguska and Sikhote-Alin falls to the whole problem of meteoritics.

Ref.

663 Krinov, E. L., 1963, The Tunguska and Sikhote-Alin meteorites, *in* Middlehurst, Barbara, and Kuiper, G. P., eds, The Moon, meteorites, and comets—The solar system, vol. 4: Chicago, Ill., Univ. of Chicago Press, p. 208–234.

The Tunguska and Sikhote-Alin impacts were witnessed falls. Scientific study of the 1908 Tunguska event was begun 19 years later; Sikhote-Alin was thoroughly investigated and analyzed before 1956. Krinov interprets conditions of fall and meteoritic material gathered from the sites.

664 Krinov, E. L., and Fonton, S. S., 1952, Discovery of meteoric dust at the place of fall of the Sikhote-Alin shower of iron meteorites: Akad. Nauk SSSR Doklady, v. 85, p. 1227–1230 [in Russian]; 1956, translated by D. Kraus in Am. Meteorolog. Soc. Contr. AF19(604)-1364, 10 p.

665 ——— 1954, Meteornaya pyl's mesta nadeniya Sichote-Alinskogo zheleznogo meteoritnogo dozhdya [Meteoric dust from the site of fall of the Sikhote-Alin iron meteoritic rain]: Meteoritika, no. 11, p. 122–131.

666 Kvasha, L. G., 1958, Mineral'nyy sostav i struktura Sichote-Alinskogo zheleznogo meteorita [Mineral composition and structure of the Sikhote-Alin iron meteorite]: Meteoritika, no. 16, p. 49–58.

667 LaPaz, Lincoln, 1949, The reported crater-producing meteoritic fall of 1947 February 12 in eastern Siberia: Pop. Astronomy, v. 57, p. 88–92; reprinted in Meteorit. Soc. Contr., v. 4, no. 3, p. 179–183.

This paper records Russian news releases and summarizes important information by E. L. Krinov, before May 1947.

668 Leonard, F. C., 1956, On the weights of the Cape York, West Greenland, and Sikhote-Alin, East Siberia, falls: Meteoritics, v. 1, no. 4, p. 495–497.

669 Levin, B. J., 1947a, The fall of a meteorite in the Far East: Astron. Tsirk., no. 60, p. 10 [in English and Russian].

670 ——— 1947b, Some additional data concerning Far East meteorite of 12 February 1947: Astron. Tsirk., no. 61, p. 4 [in Russian].

671 Miserov, A. V., 1947, Additional notes on the Sikhote-Alin meteorite fall: Priroda, v. 36, no. 9, p. 51–52 [in Russian].

672 Nature, 1949, A giant meteorite: Nature, v. 163, no. 4132, p. 92.

673 Observatory, 1947, A large Russian meteorite: Observatory, v. 67, p. 76.

674 Popular Astronomy, 1947, New meteorite craters in eastern Siberia reported: Pop. Astronomy, v. 55, p. 329; reprinted in Meteorit. Soc. Contr., v. 4, no. 1, p. 56–57.

675 ——— 1950, The meteoritic fall at Sikhote-Alinsk, U.S.S.R. (ECN $= \pm 1347, 462$) : Pop. Astronomy, v. 58, p. 40; reprinted in Meteorit. Soc. Contr., v. 4, no. 4, p. 244.

Ref.
676 Schilling, J. H., 1948, The Russian meteorite of 1947 February 12: Pop. Astronomy, v. 56, p. 389–390.

677 Schipulin, E. K., 1947, The Sikhote-Alin meteorite: Vladivostok, 40 p. [in Russian].

678 Yakonova, M. I., 1958, Khimicheskiya sostav Sichote-Alinskogo meteorita [Chemical composition of the Sikhote-Alin meteorite]: Meteoritika, no. 16, p. 42–48 [in Russian].

679 Yavnel', A. A., 1948, Structure of the Sikhote-Alin meteorites: Akad. Nauk. SSSR Doklady, v. 60, p. 1381–1384 [in Russian].

680 ——— 1950, Metamorphism phenomena in the structure of the Sikhote-Alin meteorite: Meteoritika, no. 16, p. 175–178 [in Russian].

681 ——— 1954, Otnositelyno odnorodnosti khimicheskogo sostava Sichote-Alinskogo zheleznogo meteorita [On the homogeneity of chemical composition of the Sikhote-Alin iron meteorite]: Meteoritika, no. 11, p. 107–116.

682 ——— 1956, O primesyakh v nekotorykh Sichote-Alinskogo zheleznogo meteorita [Impurities in some minerals of the Sikhote-Alin iron meteorite]: Meteoritika, no. 14, p. 87–91 [in Russian].

683 Yavnel', A. A., and Fontov, S. S., 1958, O mekhancheskoy prochnosti Sichote-Alinskogo meteorita [Mechanical strength of the Sikhote-Alin meteorite]: Meteoritika, no. 16, p. 175–178.

See also ref. 276.

SOCOTRA CRATER, SOCOTRA

(Lat 12°36′ N.; long 53°40′ E. Category 5)

684 Moore, Patrick, 1958, A meteor crater in Socotra: British Astron. Assoc. Jour., v. 68, no. 5, p. 195.

Moore reports correspondence, and one photograph, from a Mr. C. Brett who describes having seen this crater in 1942.

685 Urania Kraków, 1959, Odkrycie krateru meteorytowego na Sokotrzel [Meteor crater on Socotra]: Urania Kraków, v. 30, p. 65.

STEINHEIM BASIN, BAVARIA, GERMANY

(Lat 48°02′ N.; long 10°04′ E. Category 3)

686 Branco, Wilhelm, and Fraas, E., 1905, Das kryptovulkanische Becken von Steinheim [The cryptovolcanic Steinheim Basin]: Akad. Wiss. Berlin, Phys.-math. Kl., Abh. 1, 64 p.

In this article the authors coin the word "cryptovolcanic" to designate a structure type.

See ref. 590.

The author offers evidence that the Steinheim Basin and the Ries are not meteor craters but are of volcanic origin.

Ref.
687 Kranz, Walter, 1937, Zum Problem des Steinheimer Beckens und ähnlicher nordamerikanischer Bildungen [The problem of Steinheim Basin and similar North American formations]: Zentralbl. Mineralogie Geologie und Paläontologie, Abt. B, no. 8, p. 305–315.

Kranz describes the deposits of the Steinheim Basin and advocates an explosive origin for this cryptovolcanic structure.

688 Schwinner, Robert, 1934, Das Steinheimer Becken ein Meteor-Krater? [Is the Steinheim Basin a meteor crater?]: Deutsche Geol. Gesell. Zeitschr., v. 85, p. 801–802.

689 Silbiger, A., and Weiser F., 1951, Das Steinheimer Becken [The Steinheim Basin]: Meteorbeobachter, 1951, no. 8, p. 3.

See also refs. 235, 559, 616.

SUDBURY BASIN, ONTARIO

(Lat 46°30′ N.; long 81°01′ W. Category 6)

690 Dietz, R. S., 1962, Sudbury structure as an astrobleme [abs.]: Am. Geophys. Union Trans., v. 43, no. 4, p. 445–446.

691 ——— 1964, Sudbury structure as an astrobleme: Jour. Geology, v. 72, no. 4, p. 412–434.

The Sudbury structure is interpreted as a 1.7–billion-year-old asteroid impact structure or "astrobleme," and the terrestrial analog of a lunar mare.

692 Dietz, R. S., and Butler, L. W., 1964, Shatter-cone orientation at Sudbury, Canada: Nature, v. 204, no. 4955, p. 280–281.

693 Thomson, J. E., 1956, Geology of the Sudbury Basin: Ontario Dept. Mines Ann. Rept., no. 65, pt. 3, p. 1–56.

694 Williams, Howel, 1956, Glowing avalanche deposits of the Sudbury Basin: Ontario Dept. Mines Ann. Rept., no. 65, pt. 3, p. 57–89.

TALEMZANE CRATER, ALGERIA

(Lat 33°20′ N.; long 4°00′ E. Category 3)

695 Brady, L. F., 1954, The crater of Talemzane in Algeria: Sky and Telescope, v. 13, no. 9, p. 297–298.

See ref. 112.

No meteoritic material has been found in this vicinity. The author reviews and rejects several nonimpact theories of origin.

696 Karpoff, Roman, 1954, Un cratère de "météorite" à Talemzane dans le sud algérien [A meteorite crater at Talemzane in southern Algeria]—with discussion: Internat. Geol. Cong., 19th, Algiers 1952, Comptes rendus, sec. 13, pt. 14, p. 233–241.

TEMIMICHÂT-GHALLAMAN CRATER, MAURITANIA

(Lat 24°15′ N., long 9°39′ W. Category 6)

Ref.

See ref. 113.

This appears to the author to be an explosion crater.

See also ref. 2.

TENOUMER CRATER, MAURITANIA

(Lat 22°55′ N.; long 10°25′ W. Category 6)

697 Allix, André 1951, Note et correspondance â propos des cratères météoriques [Note and correspondence concerning some meteor craters]: Rev. Géog. Lyon, v. 26, no. 3, p. 357–359.

698 Richard-Molard, Jacques, 1948, Le cratère d'explosion de Tenoumer et l'existence probable d'une grande fracture rectiligne au Sahara occidental [The explosion crater of Tenoumer and the probable presence of a large rectilinear fracture in the western Sahara]: Acad. Sci. [Paris] Comptes Rendus, v. 227, no. 3, p. 213–214.

The fault on which the Tenoumer Crater lies, if prolonged northeast and southwest, lines up with two other known faults of the region, suggesting that they form a single great fault.

See also ref. 113.

TIFFIN CRATER, JOHNSON COUNTY, IOWA

(Lat 41°48′ N.; long 91°41′ W. Category 5)

699 Buddhue, J. D., 1938, Chemical tests of "oxide" from the Tiffin hole: Pop. Astronomy, v. 46, p. 222–224.

700 Wylie, C. C., 1937, A peculiar hole near Tiffin, Iowa: Pop. Astronomy, v. 45, p. 445–449.

701 ——— 1938, A peculiar hole near Tiffin, Iowa, second paper: Pop. Astronomy, v. 46, p. 221–222.

TUNGUSKA EVENT, PODKAMMENAYA TUNGUSKA RIVER, SIBERIA

(Lat 60°55′ N.; long 101°57′ E. Category 5)

702 Astapovitsch, I. S., 1934, New data concerning the fall of the great Tungus meteorite on June 30, 1908, in central Siberia: Astron. Zhur., v. 10, p. 465–486 [in Russian]; 1940, Pop. Astronomy, v. 48, p. 433–443, translated by Lincoln LaPaz and Gerhard Wiens, with critical commentaries by Lincoln LaPaz.

A brief resume of previous research is given here, but most attention is directed to new testimony collected between 1928 and 1932 from eyewitnesses and to sound phenomena and meteorological conditions of the day of fall collected from Siberian stations. Character of the explosion and geocentric velocity of the mass is estimated.

703 ——— 1936, New investigation into the fall of a giant meteorite in Siberia on the 30th of June, 1908: Priroda, v. 24, p. 70–72 [in Russian].

Ref.
704 Astapovitsch, I. S., 1938, On the fall of the great Siberian meteorite, June 30, 1908: Pop. Astronomy, v. 46, p. 310–317.

705 Bobrovnikoff, N. T., 1928, The Podkammenaya Tunguska meteorite: Astron. Soc. Pacific Pub., v. 40, no. 234, p. 143–145.

706 Bronshten, V. A., 1961, K voprosu o dvizhenii v atmosfere Tungusskogo meteorita [On the problem of the motion of the Tunguska meteorite through the atmosphere]: Meteoritika, no. 20, p. 72–86.

707 Burns, G. J. C., 1933, The great Siberian meteor of 1908: Pop. Astronomy, v. 41, p. 477–479.

708 Cleminshaw, C. H., 1962., Two great Siberian meteorites: Griffith Observer, v. 26, no. 9, p. 121–125.

709 Fessenkov, V. G., 1961, On the cometary nature of the Tunguska meteorite: Astron. Zhur., v. 38, no. 4, p. 577–592 [in Russian]; 1962, Soviet Astron.-AJ, v. 5, no. 4, p. 441–451, translated.

As evidence of cometary nature, Fessenkov cites the radial character of the forest around the fall site, and the abnormally bright nights subsequent to June 30 which could be attributed to small dust particles in the atmosphere.

710 ——— 1962, Ne meteorit, a kometa [A comet, not a meteorite]: Priroda, 1962, no. 8, p. 24–31.

711 ——— 1963, A note on the cometary nature of the Tungus meteorites, *in* Symposium on the astronomy and physics of meteors, Cambridge, Mass., 1961: Smithsonian Contr. Astrophysics, v. 7, p. 305–307; also in U.S. Air Force Cambridge Research Labs. Geophys. Paper no. 75, 305–307.

712 Fessenkov, V. G., and Krinov, E. L., 1960, News of Tunguska meteorite: Akad. Nauk SSSR Vestnik, no. 12, p. 32–35 [in Russian]; 1961, Los Angeles, Calif., Space Technology Labs., Inc., 8 p., translated by Z. Jabukski.

713 Florenskiy, K. P., 1963, Problema kosmicheskoi pyli i sovremennoe sostoyanne izucheniya Tungusskogo meteorita [Problem of cosmic dust and the present state of the investigation of the Tungus meteorite]: Geokhimiya, 1963, no. 3, p. 284–296; Geochemistry [English translation], 1963, no. 3, p. 301–315.

714 Florenskiy, K. P., Vronskiy, B. I., Emel'yanov, Yu. M., Zotkin, I. T., and Kirova, O. A., 1960, Predvrietel'nye rezul'taty rabot Tungusskogo meteoritnoi ekspeditsii 1958 g [Preliminary results of investigations by the Tunguska Meteoritic Expedition of 1958]: Meteoritika, no. 19, p. 103–134.

715 Florenskiy, K. P., and Zotkin, I. T., 1962, New exploration, new results (1961 Tunguska expedition): Priroda, no. 8, p. 31–39 [in Russian];

Ref.

Redondo Beach, Calif., Space Technology Labs., Inc., Translation 71, translated by Z. Jakubski.

Results obtained from processing and analyzing new data are discussed; they appear to support a southeast trajectory for the meteorite. A map drawn in 1961 is included.

716 Hogg, H. S., 1962, The Tunguska meteoric event: Royal Astron. Soc. Canada Jour., v. 56, p. 174–179.

717 Idlis, G. M., and Karyagina, Z. V., 1961, O kometnoi prirode Tungusskogo meteorita [On the cometary nature of the Tunguska meteorite]: Meteoritika, no. 21, p. 32–43.

718 Ivanov, K. G., 1961, Ob energii vzryva Tungusskogo meteorita [On the energy of the explosion of the Tunguska meteorite]: Meteoritika, no. 21, p. 44–45.

719 ——— 1963, On the height of the explosion of the Tungus meteorite: Astron. Zhur., v. 40, no. 2, p. 329–331 [in Russian, with English summary]: Soviet Astron.-AJ, v. 7, no. 2, p. 251–252, translated.

720 Kirova, O. A., 1961, O mineralogicheskom izuchenii prob pochb iz raiona padeniya Tungusskogo meteorita, sobrannykh ekspeditsili 1958 g [Mineralogical study of soil samples collected by the 1958 expedition to the area of fall of the Tunguska meteorite]: Meteoritika, no. 20, p. 32–39.

721 Krinov, E. L., 1958, Der Tungusker Meteorit [The Tungus meteorite]: Chemie der Erde, v. 19, no. 3, p. 207–229; 1960, Internat. Geology Rev., v. 2, no. 1, p. 8–19, translated by Sonia and Brandon Barringer; Meteorit. Soc. Contr., v. 6, no. 2, p. 8–19.

See ref. 663.

Krinov reviews research made and data collected and again states his preference for the comet theory of origin.

722 Kulik, L. A., 1933, Résultats préliminaires des expéditions météoriques des années 1921–1931 [Preliminary results of the meteorite expeditions of 1921–1931]: Akad. Nauk SSSR, Lomonosovskogo Inst. Geokhimii Kristallographii i Mineralogii, Trudy, v. 2, p. 73–81.

Kulik headed the first expedition, in 1927, to study the Tunguska site, 19 years after the meteorite fall.

723 ——— 1935, On the fall of the Podkamennaya Tunguska meteorite in 1908, translated from the Russian: Pop. Astronomy, v. 43, p. 596–599.

724 ——— 1937, The question of the meteorite of June 30, 1908, in central Siberia: Pop. Astronomy, v. 45, p. 273–275.

725 ——— 1939, Data on the Tungus meteorite as available towards 1939: Akad. Nauk SSSR Comptes Rendus, Doklady, new ser., v. 22, no. 8, p. 515–519.

Ref.
726 Kulik, L. A., 1960, The Tunguska meteorite, with commentary by E. L. Krinov, *in* Shapley, Harlow, ed., Source book in astronomy, 1900–1950: Cambridge, Mass., Harvard Univ. Press, p. 75–81.

This is a translation of a paper read in Denver, Colo., 1937.

727 Levin, B. J., 1954, K voprosy o skorosti i orbite Tungusskogo meteorita [On the problem of the velocity and the orbit of the Tunguska meteorite]: Meteoritika, no. 11, p. 132–134.

728 Obashev, S. O., 1961, O geomagnitom effekte Tungusskogo meteorita [On the geomagnetic effect of the Tunguska meteorite]: Meteoritika, no. 21, p. 49–51.

729 Sawyer, H. S., 1962, The Tunguska meteoric event: Royal Astron. Soc. Canada Jour., v. 56, p. 174–179.

730 Stanyukovich, K. P., and Bronshten, V. A., 1961, O skorosti i energii Tungusskogo meteorita [Velocity and energy of the Tungusk meteorite]: Akad. Nauk SSSR Doklady, v. 140, no. 3, p. 583–586; 1962, U.S. Natl. Aeronautics and Space Adm. Tech. Translation F–89, 7 p.

731 Sytinskaya, N. N., 1955, K voprosy o traektoriy Tungusskogo meteorita [On the problem of the trajectory of the Tunguska meteorite]: Meteoritika, no. 13, p. 86–91.

732 Treskov, A., 1935, On seismic waves which accompanied the fall of the meteorite on June 30, 1908: Astron. Zhur., v. 11, p. 597–599 [in Russian, with English summary].

733 Whipple, F. J., 1934, On phenomena related to the great Siberian meteor: Royal Meteorolog. Soc. Quart. Jour., v. 60, p. 505–512.

Whipple was the first to favor a cometary origin for the Tunguska event.

734 Zolotov, A. V., 1961, Some recent data on the Tunguska catastrophe of 1908: Akad. Nauk SSSR Doklady, v. 136, no. 1, p. 84–87 [in Russian]; 1962, Akad. Nauk SSSR Doklady, Earth Sci. Sec., v. 136, nos. 1–6, p. 160–162, translated.

735 Zotkin, I. T., 1961, Ob anomal'nykh opticheskikh yavleniyakh v atmosfere, sryazannykh s nadeniem Tungusskogo meteorita [The fall of the Tunguska meteorite and related optical phenomena in the atmosphere]: Meteoritika, no. 20, p. 40–53.

TVÄREN BAY, SWEDEN

(Lat 58°46′ N.; long 17°25′ E. Category 6)

See ref. 457.

UNGAVA BAY, QUEBEC

(Lat 60°00′ N.; long 67°20′ W. Category 6)

See ref. 13.

UNGAVA CRATER, QUEBEC

(*See* New Quebec Crater)

UPHEAVAL DOME, SAN JUAN COUNTY, UTAH

(Lat 38°27′ N.; long 109°56′ W. Category 5)

Ref.

See ref. 2.

"A highly dissected cryptovolcanic structure with a central dome about 1½ miles across."

736 McKnight, E. T., 1940, Geology of area between Green and Colorado rivers, Grand and San Juan counties, Utah: U.S. Geol. Survey Bull. 908, 147 p.

See also ref. 20.

VERSAILLES STRUCTURE, WOODFORD COUNTY, KY.

(Lat 38°02′ N.; long 84°45′ W. Category 4)

737 Black, D. F. B., 1963, Geologic and structure map of a cryptoexplosion structure near Versailles, Kentucky: U.S. Geol. Survey open-file map.

738 ——— 1964, Cryptoexplosion structure near Versailles, Kentucky: U.S. Geol. Survey Prof. Paper 501–B, p. B9–B12.

The author describes a circular structure, nearly 1 mile in diameter, with a highly brecciated central dome and a rim structure which might indicate a meteoritic origin.

VREDEFORT STRUCTURE, SOUTH AFRICA

(Lat 27°28′ S.; long 27°29′ E. Category 4)

739 Bishopp, D. W., 1941, The geodynamics of the Vredefort dome: Geol. Soc. South Africa Trans., v. 44, p. 1–18.

The paper reviews some earlier theories of the Vredefort "dome" and the question of centrifugal or centripetal pressure in arching up the central circular region with its flanking ring of overturned sediments.

740 ——— 1962, The Vredefort Ring—A further discussion: Jour. Geology, v. 70, no. 4, p. 500–502.

741 Bisschoff, A. H., 1962, The pseudotachylite of the Vredefort Dome: Geol. Soc. South Africa Trans. and Proc., v. 65, pt. 1, p. 207–226; discussion by W. I. Manton, p. 227–228; author's reply to discussion, p. 228–230.

742 Brock, B. B., 1951, The Vredefort ring: Geol. Soc. South Africa Trans. and Proc., v. 53, p. 131–157.

743 Daly, R. A., 1947, The Vredefort ring-structure of South Africa: Jour. Geology, v. 55, no. 3, p. 125–145.

Daly summarizes five explanations attributing the deformation of the Vredefort to terrestrial forces, then seriously considers the Boon and Albritton suggestion (ref. 18) of a meteorite of asteroid dimensions.

744 Dietz, R. S., 1961, Vredefort Ring structure—Meteorite impact scar?: Jour. Geology, v. 69, no. 5, p. 499–516.

The author suggests that the Vredefort Ring, with its crater diameter of 40 km, is the result of an impact similar in force to that which created Tycho or Copernicus on the Moon.

Ref.
745 Dietz, R. S., 1962, The Vredefort Ring—A reply: Jour. Geology, v. 70, no. 4, p. 502–504.

A reply to D. W. Bishopp, ref. 740.

746 Ellis, J., 1945, Discussion of a paper by B. D. Maree, "The Vredefort structure as revealed by a gravimetric survey": Geol. Soc. South Africa Proc. [v. 48], p. 55–57.

747 Hall, A. L., and Molengraaff, G. A. F., 1925, The Vredefort Mountain Land in Southern Transvaal and northern Orange Free State: Nederlandse Akad. Wetensch. Verh., sec. 2, pt. 24, no. 3, p. 1–183.

748 Hargraves, R. B., 1961, Shatter cones in the rocks of the Vredefort Ring: Geol. Soc. South Africa Trans. and Proc., v. 64, p. 147–154; discussions by B. B. Brock, R. S. Dietz, J. G. Ramsay, A. B. A. Brink, and K. Knight, with reply by the author, p. 155–161.

Hargraves finds shatter cones abundant in almost all rocks of the Vredefort area and concludes that the radial orientation of cones found in Witwatersrand quartzites points to a shock locus situated approximately in the center of the ring.

749 ——— 1962, Review of geologic evidence, opinion, and current research relevant to the impact origin of the Vredefort ring [abs.]: Jour. Geophys. Research, v. 67, no. 9, p. 3563.

750 Maree, B. D., 1944, The Vredefort structure as revealed by a gravimetric survey: Geol. Soc. South Africa Trans., v. 47, p. 183–196.

Gravitational anomalies reveal that the Vredefort structure is pear-shaped, its smaller end, the covered portion, pointing to the southeast. Maree uses this information to explain a new theory of origin.

751 Molengraaff, G. A. F., 1904, Geology of the Transvaal, translated from the French by J. H. Ronaldson: Edinburgh, T. and A. Constable, 90 p.

752 Nel, L. T., 1927, The geology of the country around Vredefort—An explanation of the geological map: Pretoria, South Africa Geol. Survey, 134 p.

753 Poldervaart, Arie, 1962, Notes on the Vredefort dome: Geol. Soc. South Africa Trans. and Proc., v. 68, pt. 1, p. 231–247; discussion by A. A. Bisschoff, p. 249–251; author's reply to discussion, p. 251.

754 Shand, J. S., 1916, The pseudotachylyte of Parijs (Orange Free State), and its relation to "trap-shotten gneiss" and "flinty crush-rock": Geol. Soc. London Quart. Jour., v. 72, p. 198–221.

755 Truter, F. C., 1941, Discussion on the paper by D. W. Bishopp, "The geodynamics of the Vredefort Dome": Geol. Soc. South Africa Proc., v. 44. p. 84–89.

756 Weiss, Oscar, 1949, Aerial magnetic survey of the Vredefort dome in the Union of South Africa: Mining Eng., v. 1, no. 12, p. 433–438.

See also refs. 18, 22, 38, 79.

WABAR CRATERS, SAUDI ARABIA

(Alternate name: Al Hadida Craters. Lat 21°30′ N.; long 50°28′ E. One to four craters. Category 1)

Ref.

757 Bartrum, C. O., 1932, Meteorite craters in Arabia and Ashanti: British Astron. Assoc. Jour., v. 42, no. 9, p. 398–399.

758 Chao, E. C. T., Fahey, J. J., and Littler, Janet, 1961, Coesite from Wabar crater, near Al Hadida, Arabia: Science, v. 133, no. 3456, p. 882–883.

This reports the third natural occurrence of coesite, the high pressure polymorph of silica. Wabar is the smallest of three craters where coesite has been found.

759 Halbfass, William, 1933, Ein Meteoritenkrater in Südarabien [A meteorite crater in Saudi Arabia]: Petermanns Mitt., v. 79, no. 3–4, p. 72.

760 Holm, D. A., 1962, New meteorite localities in the Rub' al Khali, Saudi Arabia: Am. Jour. Sci., v. 260, no. 4, p. 303–309.

Of 16 localities in which meteoritic material has been found, only centrally located Al Hadida has craters. This article summarizes investigations made in the Rub' al Khali and adds notes taken from the exploration file of the Arabian American Oil Co.

761 Philby, H. St. J., 1932, Rub' al Khali: Royal Central Asian Soc. Jour., v. 19, pt. 4, p. 569–586.

762 ——— 1933a, The empty quarter, with appendix by L. J. Spencer: New York, Henry Holt, p. 157–180, 365–359.

763 ——— 1933b, Rub' al Khali—An account of exploration in the Great South Desert of Arabia: Geog. Jour. [London], v. 81, no. 1, p. 1–26.

See also refs. 141, 372.

WELLS CREEK AREA, STEWART COUNTY, TENN.

(Alternate names: Cave Spring Hollow, Indian Mound. Lat 36°23′ N.; long 87°40′ W. Four structures. Categories 4, 6)

764 Wilson, C. W., Jr., 1953, Wilcox deposits in explosion craters, Stewart County, Tennessee, and their relations to origin and age of Wells Creek Basin structure: Geol. Soc. America Bull., v. 64, no. 7, p. 753–768.

It is concluded that four craters had a common post-Eutaw, pre-Wilcox age and common origin by the impact and resulting explosions of fragments of a meteor. A 2,000-foot core drilled in the center of Wells Creek Basin is summarized.

See also refs. 20, 22.

WEST HAWK LAKE, MANITOBA

(Lat 49°46′ N.; long 95°12′ W. Category 6)

Ref.

765 Halliday, Ian, and Griffin, A. A., 1963a, Evidence in support of a meteoric origin for West Hawk Lake, Manitoba, Canada: Jour. Geophys. Research, v. 68, no. 18, p. 5297–5306.

Gravity readings from the lake ice indicate a residual negative anomaly of 6 milligals associated with this feature. The authors suggest an original rim diameter of 12,000 feet, modified by glaciation and erosion.

766 ——— 1963b, West Hawk Lake—Manitoba's ancient crater and modern resort: Royal Astron. Soc. Canada Jour., v. 57, no. 1, p. 24.

See also ref. 50.

WETHERBEE CRATER, LABRADOR

(*See* Merewether Crater)

WILBARGER DOME, WILBARGER COUNTY, TEX.

(Lat 33°50′ N.; long 99°15′ W. Category 6)

767 Hughes, U. B., 1932, Shallow salt-type structure in Permian of north-central Texas: Am. Assoc. Petroleum Geologists Bull., v. 16, no. 6, p. 577–583; abs. in Pan-Am. Geologist, v. 57, no. 4, p. 305.

768 Monnig, O. E., 1963, A probable small astrobleme in north Texas: Meteoritics, v. 2, no. 1, p. 71.

Hughes had attributed disturbance in this area to movement of gypsiferous shales; Monnig is convinced that a meteoritic origin is more likely.

WILKES LAND STRUCTURE, ANTARCTICA

(Lat 71° S.; long 140° E. Category 6)

769 Schmidt, R. A., 1962, Australites and Antarctica: Science, v. 138, no. 3538, p. 443–444.

"A meteorite crater in the Wilkes Land region of Antarctica has been postulated as an explanation of the origin of australites. Geophysical data suggest that such a feature may have been located."

770 Scientific American, 1962, Tektite crater: Sci. Am., v. 207, no. 12, p. 68–69.

WINKLER CRATER, RILEY COUNTY, KANS.

(Lat 39°29′ N.; long 96°49′ W. Category 6)

See ref. 3.

WOLF CREEK CRATER, WESTERN AUSTRALIA

(Lat 19°18′ S.; long 127°46′ E. Category 1)

771 Cassidy, W. A., 1954, The Wolf Creek, Western Australia, meteorite crater (CN=—1278,192): Meteoritics, v. 1, no. 2, p. 197–199.

Ref.

772 Guppy, D. J., and Matheson, R. S., 1950, Wolf Creek meteorite crater, Western Australia: Jour. Geology, v. 58, p. 30–36; 1951, reprinted in Smithsonian Inst. Ann. Rept. 1950, p. 317–325.

The Wolf Creek Crater is the second largest crater known to be of meteoritic origin. Its age is here considered to be Pleistocene or Recent.

773 Holmes, C. H., 1948, The hidden crater of Wolf Creek: Walkabout, v. 14, no. 13, p. 10–16.

774 ——— 1949, The hidden crater of Wolf Creek: Sky and Telescope, v. 8, no. 7, p. 163–164.

775 LaPaz, Lincoln, 1954, Meteoritic material from the Wolf Creek, Western Australia, crater (CN=1278,192): Meteoritics, v. 1, no. 2, p. 200–203.

This report describes two masses of meteoritic material recovered by W. A. Cassidy (ref. 771) and analyzed by the Institute of Meteoritics.

776 Leonard, F. C., 1949, Further evidence concerning the Wolf Creek, Western Australia, crater: Pop. Astronomy, v. 57, p. 405–406; reprinted in Meteorit. Soc. Contr., v. 4, no. 3, p. 214–215.

777 ——— 1949b, Is the crater of Wolf Creek, Western Australia (—1278,192) meteoritic?: Pop. Astronomy, v. 57, p. 138–140; reprinted in Meteorit. Soc. Contr., v. 4, no. 3, p. 188–190.

778 ——— 1949c, More about the Wolf Creek, Western Australia crater: Pop. Astronomy, v. 57, p. 345–346; reprinted in Meteorit. Soc. Contr., v. 4, no. 3, p. 205–206.

779 ——— 1949d, Wolf Creek Crater, Australia: Pop. Astronomy, v. 57, p. 337–338.

780 Nininger, H. H., 1949, [Wolf Creek Crater]: Sky and Telescope, v. 8, no. 12, p. 298.

781 Preuss, Ekkehard, 1951, Der Wolf Creek Meteoritenkrater in Westaustralien [The Wolf Creek meteorite crater in Western Australia]: Sternenwelt, v. 3, p. 113.

782 Reeves, Frank, and Chalmers, R. O., 1949, Wolf Creek crater: Australian Jour. Sci., v. 11, p. 154–156.

Reeves, a geologist, was in a party of three who spotted the crater from the air in June 1947. He describes their original theory of volcanic origin and subsequent reasons for change to the impact hypothesis.

See also ref. 73.

INDEXES

AUTHOR INDEX

A

B

C

INDEX OF ALTERNATE NAMES

[See "Contents" for other names]

U.S. GOVERNMENT PRINTING OFFICE:1966