IN THE SUPREME COURT OF THE STATE OF NEVADA

EUREKA COUNTY, A POLITICAL SUBDIVISION OF THE STATE OF NEVADA; KENNETH F. BENSON, INDIVIDUALLY; DIAMOND CATTLE COMPANY, LLC, A NEVADA LIMITED LIABILITY COMPANY; AND MICHEL AND MARGARET ANN ETCHEVERRY FAMILY, LP, A NEVADA REGISTERED FOREIGN LIMITED PARTNERSHIP,

Appellants,

vs.

THE STATE OF NEVADA STATE ENGINEER; THE STATE OF NEVADA DIVISION OF WATER RESOURCES; AND KOBEH VALLEY RANCH, LLC, A NEVADA LIMITED LIABILITY COMPANY,

Respondents.

______________________________________/

Case No. 61324

District Court Case Nos.
CV 1108-15; CV 1108-156;
CV 1108-157; CV 1112-164;
CV 1112-165; CV 1202-170

JOINT APPENDIX
Volume 24

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Docket 61324 Document 2012-40916

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CHRONOLOGICAL APPENDIX TO APPEAL FROM JUDGMENT

DOCUMENT	DATE	VOL	JA NO.
Petition for Judicial Review	08/08/2011	1	01-06
Notice of Verified Petition for Writ of Prohibition, Complaint and Petition for Judicial Review	08/10/2011	1	07- 08
Verified Petition for Writ of Prohibition, Complaint and Petition for Judicial Review	08/10/2011	1	09-59
Summons and Proof of Service, Kobeh Valley Ranch, LLC	08/11/2011	1	60-62
Summons and Proof of Service, Jason King	08/11/2011	1	63-65
Affidavit of Service by Certified Mail	08/11/2011	1	66-68
Notice of Petition for Judicial Review	08/11/2011	1	69-117
Summons and Proof of Service, Kobeh Valley Ranch, LLC	08/15/2011	1	118-120
Summons and Proof of Service, Jason King	08/15/2011	1	121-123
Summons and Proof of Service, The State of Nevada	08/17/2011	1	124-128
First Additional Summons and Proof of Service, State Engineer, Division of Water Resources	08/17/2011	1	129-133
Order Allowing Intervention of Kobeh Valley Ranch, LLC, to Intervene as a Respondent	09/14/2011	1	134-135

DOCUMENT	DATE	VOL	JA NO.
Partial Motion to Dismiss, Notice of Intent to Defend	09/14/2011	1	136-140
Order Allowing Intervention of Kobeh Valley Ranch, LLC, as a Party Respondent	09/26/2011	1	141-142
Answer to Verified Petition for Writ of Prohibition, Complaint and Petition for Judicial Review by Kobeh Valley Ranch, LLC	09/28/2011	1	143-149
Answer to Petition for Judicial Review by Kobeh Valley Ranch, LLC	09/29/2011	1	150-154
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Order Directing the Consolidation of Action CV1108-156 and Action No. CV1108-157 with Action CV1108-155	10/26/2011	1	161-162
Summary of Record on Appeal	10/27/2011	2-26	163-5026
Request for and Points and Authorities in Support of Issuance of Writ of Prohibition and in Opposition to Motion to Dismiss	11/10/2011	27	5027-5052
Order Setting Briefing Schedule	12/02/2011	27	5053-5055
Reply in Support of Partial Motion to Dismiss and Opposition to Request for Writ of Prohibition	12/15/2011	27	5056-5061

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Kobeh Valley Ranch's Reply to Conley/Morrison's Request for and Points and Authorities in Support of Issuance of Writ of Prohibition and in Opposition to Motion to Dismiss	12/15/2011	27	5062-5083
Kobeh Valley Ranch's Joinder in the State of Nevada and Jason King's Partial Motion to Dismiss	12/15/2011	27	5084-5086
Petition for Judicial Review	12/29/2011	27	5087-5091
Petition for Judicial Review	12/30/2011	27	5092-5097
Summons and Proof of Service, The State of Nevada	01/11/2012	27	5098-5100
First Additional Summons and Proof of Service, State Engineer, Division of Water Resources	01/11/2012	27	5101-5103
First Amended Petition for Judicial Review	01/12/2012	27	5104-5111
Opening Brief of Conley Land & Livestock, LLC and Lloyd Morrison	01/13/2012	27	5112-5133
Petitioners Kenneth F. Benson, Diamond Cattle Company, LLC, and Michel and Margaret Ann Etcheverry Family LP's Opening Brief	01/13/2012	27	5134-5177
Eureka County's Opening Brief	01/13/2012	27	5178-5243
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Eureka County's Supplemental Summary of Record on Appeal - CV1108-155	01/13/2012	29-30	5421-5701

DOCUMENT	DATE	VOL	JA NO.
Order Granting Extension	01/26/2012	31	5702-5703
Answer to Petition for Judicial Review	01/30/2012	31	5704-5710
Answer to First Amended Petition for Judicial Review	01/30/2012	31	5711-5717
Supplemental Petition for Judicial Review	01/31/2012	31	5718-5720
Petition for Judicial Review	02/01/2012	31	5721-5727
Summary of Record on Appeal	02/03/2012	31	5728-5733
Record on Appeal, Vol. I, Bates Stamped Pages 1-216	02/03/2012	31	5734-5950
Record on Appeal, Vol. II, Bates Stamped Pages 217-421	02/03/2012	32	5951-6156
Record on Appeal, Vol. III, Bates Stamped Pages 422-661	02/03/2012	33	6157-6397
Answer to Petition to Judicial Review	02/23/2012	34	6398-6403
Answering Brief	02/24/2012	34	6404-6447
Respondent Kobeh Valley Ranch, LLC's Answering Brief	02/24/2012	34	6448-6518
Reply Brief of Conley Land & Livestock, LLC and Lloyd Morrison	03/28/2012	34	6519-6541
Petitioners Kenneth F. Benson, Diamond Cattle Company, LLC, and Michel and Margaret Ann Etcheverry Family LP's Reply Brief	03/28/2012	34	6542-6565
Eureka County's Reply Brief	03/28/2012	34	6566-6638

ALPHABETICAL APPENDIX TO APPEAL FROM JUDGMENT

DOCUMENT	DATE	VOL	JA NO.
Order Allowing Intervention of Kobeh Valley Ranch, LLC, to Intervene as a Respondent	09/14/2011	1	134-135
Order Allowing Intervention of Kobeh Valley Ranch, LLC, as a Party Respondent	09/26/2011	1	141-142
Order Directing the Consolidation of Action CV1108-156 and Action No. CV1108-157 with Action CV1108-155	10/26/2011	1	161-162
Order Setting Briefing Schedule	12/02/2011	27	5053-5055
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Petition for Judicial Review	12/30/2011	27	5092-5097
Petition for Judicial Review	02/01/2012	31	5721-5727
Petitioners Kenneth F. Benson, Diamond Cattle Company, LLC, and Michel and Margaret Ann Etcheverry Family LP's Opening Brief	01/13/2012	27	5134-5177
Petitioners Kenneth F. Benson, Diamond Cattle Company, LLC, and Michel and Margaret Ann Etcheverry Family LP's Reply Brief	03/28/2012	34	6542-6565
Petitioners Benson, Diamond Cattle Co., and Etcheverry Family LP's Notice of Appeal	07/12/2012	36	6950-6951

DOCUMENT	DATE	VOL	JA NO.
Record on Appeal, Vol. II, Bates Stamped Pages 217-421	02/03/2012	32	5951-6156
Record on Appeal, Vol. I, Bates Stamped Pages 1-216	02/03/2012	31	5734-5950
Record on Appeal, Vol. III, Bates Stamped Pages 422-661	02/03/2012	33	6157-6397
Reply in Support of Partial Motion to Dismiss and Opposition to Request for Writ of Prohibition	12/15/2011	27	5056-5061
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Respondent Kobeh Valley Ranch, LLC's Answering Brief	02/24/2012	34	6448-6518
Summary of Record on Appeal	10/27/2011	2-26	163-5026
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Summons and Proof of Service, Kobeh Valley Ranch, LLC	08/11/2011	1	60-62
Summons and Proof of Service, Jason King	08/11/2011	1	63-65
Summons and Proof of Service, Jason King	08/15/2011	1	121-123
Summons and Proof of Service, Kobeh Valley Ranch, LLC	08/15/2011	1	118-120

DOCUMENT	**DATE**	**VOL**	**JA NO.**
Summons and Proof of Service, The State of Nevada	08/17/2011	1	124-128
Summons and Proof of Service, The State of Nevada	01/11/2012	27	5098-5100
Supplemental Petition for Judicial Review	01/31/2012	31	5718-5720
Transcript for Petition for Judicial Review	04/03/2012	35	6639-6779
Verified Petition for Writ of Prohibition, Complaint and Petition for Judicial Review	08/10/2011	1	09-59

CERTIFICATE OF APPENDIX (NRAP 30(g)(1)

In compliance with NRAP 30(g)(1) I hereby certify that this Appendix consists of true and correct copies of the papers in the District Court file.

DATED: December 21, 2012.

/s/ KAREN A. PETERSON
KAREN A. PETERSON, NSB #366
ALLISON, MacKENZIE, PAVLAKIS, WRIGHT & FAGAN, LTD.
P.O. Box 646
Carson City, NV 89702

Attorneys for Appellant,
EUREKA COUNTY

IN THE OFFICE OF THE STATE ENGINEER OF THE STATE OF NEVADA

FILED
JUL 10 2009
STATE ENGINEER'S OFFICE

2009 JUL 10 PM 3:45

IN THE MATTER OF APPLICATION NUMBER. 78271
FILED BY. GENERAL MOLY, INC., A DELAWARE CORPORATION
ON APRIL 17, 2009, TO APPROPRIATE THE
WATERS OF UNDERGROUND (EUREKA COUNTY)

PROTEST

Comes now EUREKA COUNTY
Printed or typed name of protestant

whose post office address is P.O. BOX 677, EUREKA, NEVADA 89316
Street No. Or P.O. Box, City, State and Zip Code.

whose occupation is POLITICAL SUBDIVISION and protests the granting

of Application Number 78271 filed on APRIL 17, 2009

by GENERAL MOLY, INC., a Deleware corporation to appropriate the

waters of UNDERGROUND situated in EUREKA
Underground or name of stream, lake, spring or other source

County, State of Nevada, for the following reasons and on the following grounds, to wit:

SEE EXHIBIT "A" ATTACHED

THEREFORE the Protestant requests that the application be DENIED
Denied, issued subject to prior rights, etc., as the case may be

and that an order be entered for such relief as the State Engineer deems just and proper.

Signed ....
Agent or protestant

J.P. "JIM" ITHURRALDE, CHAIRMAN, CO. COMMISSIONERS
Printed or typed name, if agent

Address P.O. Box 677
Street No. or P.O. Box No.

EUREKA, NEVADA 89316
City, State and Zip Code No.

Subscribed and sworn to before me this 25TH day of JUNE 2009

JACKIE J. BERG
NOTARY PUBLIC, STATE OF NEVADA
EUREKA COUNTY• NEVADA
CERTIFICATE # 05-10[illegible]-8
APPT. EXP. OCT. 6, 2[illegible]

Notary Public

State of NEVADA

County of EUREKA

$25 FILING FEE MUST ACCOMPANY PROTEST. PROTEST MUST BE FILED IN DUPLICATE. ALL COPIES MUST CONTAIN ORIGINAL SIGNATURE.

C:\DOCUMENTS AND SETTINGS\NVALDEZ\LOCAL SETTINGS\TEMPORARY INTERNET FILES\CONTENT.OUTLOOK\DA84Q1MM\PROTEST 78271.DOC

Exhibit "A"
Eureka County Protest to General Moly, Inc.
Application No. 78271

1. Application 78271 was filed on April 17, 2009 by General Moly, Inc. to appropriate groundwater for irrigation and domestic purposes on the Bean Flat Ranch. In Ruling 5966 issued by the State Engineer on March 26, 2009, the State Engineer stated that the perennial yield of the Kobeh Valley Hydrographic Basin was 16,000 acre-feet annually and with the grant of the applications the subject of Ruling 5966, the total committed ground-water resources of the basin would be approximately 12,400 acre-feet annually. *Ruling 5966* at page 26. There are 3,600 acre-feet of water rights available for appropriation in the basin. With a duty of 4 acre foot per acre, granting Application 78271 which proposes to irrigate approximately 460.07 acres would require the approval of 1,840.28 acre-feet of additional water rights in the basin. On April 17, 2009, Kobeh Valley Ranch LLC, owned by General Moly, Inc., filed four other applications for irrigation purposes to irrigate 1,584.33 acres on the Bobcat Ranch. Granting the four applications to irrigate the Bobcat Ranch would require the approval of 6,337.32 acre-feet annually of additional water rights in the basin. These five applications seek to appropriate a total of 8,177.60 acre-feet of water rights. There is not 8,177.60 acre-feet annually of water available for appropriation in the basin and granting the subject applications as requested will exceed the perennial yield of the basin.

2. General Moly, Inc. owns Kobeh Valley Ranch, LLC, which previously filed numerous change applications seeking to change the point of diversion, manner of use and place of use of existing irrigation water rights for use in General Moly, Inc.'s mining project. Ruling 5966 issued March 26, 2009 ruled on numerous irrigation water rights held by Kobeh Valley Ranch, LLC. Kobeh Valley Ranch, LLC sought to change the point of diversion, place of use and manner of use of its Bean Flat irrigation rights for use in General Moly, Inc.'s mining project. Three weeks after Ruling 5966, the applicant filed the subject application seeking to appropriate water for the Bean Flat Ranch at the same point of diversion, in the same place of use and for the same manner of use as some of its change applications the subject of Ruling 5966. Eureka County does not believe the applicant intends in good faith to put the water to beneficial use for the stated purposes.

3. At the protest hearing held October 13-October 17, 2008 with regard to the Mt. Hope Mine Project, the applicant's witness never testified that the applicant, General Moly, Inc. was formed or in any way involved in the agricultural business and intended to operate the Bean Flat Ranch for agricultural purposes. A review of General Moly, Inc.'s website indicates that it is a mining company not an agricultural company. One of the applicant's witnesses testified at the hearing: ". . . the only thing we intend to do with the water rights is use them for mining and milling purposes at the Mount Hope project." Volume III Transcript of Proceedings, Public Hearing, Wednesday, October 15, 2008, page 515, lines 2-4.

4. The testimony at the protest hearing held October 13-October 17, 2008 with regard to the Mt. Hope Mine Project was that the Bean Flat Ranch water rights may be used as an option to supply water to the mine project if there were impacts from pumping at the mine's other well locations. If the application was filed for use as additional water for the applicant's mining project, the application violates the intent of Ruling 5966, which determined that the

applicant had only shown a need for the use of 11,300 acre-feet annually of water rights for its Mt. Hope Mine Project.

5. If the intent of this application is to acquire more water rights for mitigation purposes for its mining project, Eureka County does not believe the applicant intends in good faith to put the water to beneficial use for the stated purposes.

6. Kobeh Valley is a designated basin. The perennial yield of the basin is approximately 16,000 acre-feet per year, which assumes that the natural groundwater discharge (phreatophyte evapotranspiration) from the basin can be captured over the long term per a study prepared for General Moly. In Kobeh Valley, most naturally recharged groundwater is discharged by phreatophytic vegetation on the valley floor, with a reconnaissance-level evapotranspiration estimate by the USGS of 15,000 acre-feet per year. Most of the valley floor phreatophytic vegetation will continue to occur notwithstanding the mine's pumping and applicant's proposed pumping for the irrigation of 460.07 acres. The groundwater discharged in the Kobeh Valley hydrographic basin by phreatophytic vegetation and the mine's pumping will total approximately 26,300 acre-feet per year. In addition, General Moly's model simulates 1,900 acre-feet per year inflow from Kobeh Valley to Diamond Valley. These total amounts are in excess of the perennial yield of the basin and result in an overdraft situation for the basin. Granting the subject applications will cause the basin to be over pumped to the detriment of the basin and prior existing water rights holders.

7. Existing USGS reports suggest that Kobeh Valley may provide underground flow to Diamond Valley. The applicant's groundwater model simulates such an underflow also. Sustained over pumping in Kobeh Valley is likely to reduce that amount and affect prior existing municipal water rights held by Eureka County and Devils Gate GID that supply the majority of the population in Diamond Valley. The Diamond Valley Regional Flow System is being studied at the present time by the USGS. The grant of any further applications in this basin should not be considered until the USGS study is complete and the additional analysis and data acquisition that will be conducted to improve the technical adequacy of the mine's studies are complete.

8. Sustained over-pumping in Kobeh Valley is likely to impact irrigation and stockwatering water right holders, impact domestic well owners and surface water flows in Kobeh Valley. Sustained over-pumping in Kobeh Valley may impact irrigation and stockwatering water rights, domestic well owners and surface water rights in Diamond Valley. The owners of these rights contribute to the long-term economic viability of the greater Eureka community; therefore, unless adequately mitigated, such impacts may prove detrimental to the health and welfare of Eureka County.

9. The applicant must provide proof satisfactory to the State Engineer that there is a reasonable expectation of the financial ability to apply the water to the intended beneficial use with reasonable diligence and of its good faith intention to apply the water to the intended beneficial use with reasonable diligence. Since the hearing evidence was

presented, General Moly has issued numerous press releases regarding the Mt. Hope Mine Project and its financial situation. On March 26, 2009, General Moly announced further cash conservation efforts to preserve its current cash balance. In a newspaper article dated November 7, 2008, General Moly's chief executive officer indicated that the mine project might be put on hold in early 2009. At the close of the stock market trading on May 1, 2009, General Moly's stock price was $1.52 a share, down from a 52 week high of $9.69 per share. The 52 week low for General Moly shares was $0.64 per share. General Moly's most recent Form 8-K filed with the Securities and Exchange Commission (Date of Earliest Event Reported: March 26, 2009) indicates interim financing is not in place. In addition, there is no reasonable probability that the financing necessary for the mine project (estimated costs of over $1 billion) is available to General Moly to go forward with the project or is forthcoming. The application states that the estimated cost of the works for irrigation purposes is $100,000. The applicant has not shown the State Engineer proof satisfactory of its financial ability and reasonable expectation actually to apply the water to the intended beneficial use with reasonable diligence.

10. Should this protest result in a hearing before the State Engineer, Eureka County requests that any such hearing be held in Eureka to facilitate access by protestant.

GEOLOGY OF WHISTLER MOUNTAIN, EUREKA COUNTY, NEVADA

by

Dennis James Low

A THESIS

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Geology

Under the Supervision of Professors S. B. Treves

and R. B. Nelson

Lincoln, Nebraska

May, 1982

ACKNOWLEDGMENTS

I would like to acknowledge the time and effort that Dr. S. B. Treves devoted to this thesis. His guidance, comments, and constructive criticism concerning field work and writing are sincerely appreciated. I would also like to thank Dr. Nelson for his help with the interpretation of numerous structural problems, Drs. R. Smith and W. Wayne for their help in interpretation of geophysical and geomorphic evidence, respectively, and Dr. R. Goble for his comments and criticism. I am indebted to Mrs. D. Busch for the typing of this thesis, and to Mr. D. Busch for his helpful comments. Special thanks are due to the support of my parents, Mr. and Mrs. H. G. Low, my fiance, Nancy Nelson, and Rev. and Mrs. R. Raabe.

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ABSTRACT

The Whistler Mountain pluton is one of many quartz-monzonite and granodiorite Jurassic plutons of north-central Nevada, which were intruded along pre-existing, north-trending, zones of weakness associated with past deformation. It is epizonal, probably a laccolith, consists of aplitic quartz-monzonite and is intrusive into Paleozoic sedimentary rocks of the eastern, western, and overlap assemblages of central Nevada. Felsite sills from the main igneous body intrude bedding planes of the Devonian Devils Gate Limestone and an unconformable contact between the Devonian limestone and Mississippian clastics.

Emplacement was shallow, less than 10,000 ft, as determined by contact relationships, and textural and mineralogic features. Prior to complete cooling, pneumatolytic, boron-bearing fluids and/or gases migrated along early formed cooling joints. Boron reacted with biotite and feldspar to form disseminated tourmaline spots and nodules and tourmaline-bearing joints; some of which were resealed. Late stage quartz-veins and dikes were emplaced and alteration of the feldspar occurred.

During the Pleistocene, several lakes were present in Diamond and Kobeh Valleys. Sometime in the Pleistocene, the lake in Kobeh Valley overflowed and eroded a col at Devils Gate and drained eastward into Diamond Valley. The

climate at this time was moist and cool. At glacial maxima, periglacial features developed on Whistler Mountain. As the climate warmed, the lake in Diamond Valley began to contract, leaving remnant lake terraces.

INTRODUCTION

This thesis is concerned with the geology of the Whistler Mountain pluton and nearby areas. In the following special attention is given to the petrography of the rocks that constitute Whistler Mountain and the geomorphic features of the mountain and surrounding areas. This thesis is a detailed study of the pluton and the intruded rocks, and presents detailed geophysical, geomorphic, and structural data that have been used to formulate the geologic history of this area. It, hopefully, will be a contribution that will advance knowledge of the Basin and Range geology.

Location and Accessibility

Whistler Mountain (figs. 1, 2) is located 10 miles northwest of the town of Eureka, in Eureka County, Nevada, and is included on the topographic map of the Whistler Mountain quadrangle, 15 minute series, lat. 39° 30' - 39° 45' and long. 116° 00' - 116° 15', which was published by the U.S. Geol. Surv. in 1956.

The southern portion of the map area is easily accessible from U.S. Highway 50 and adjacent dirt roads. The eastern portion of the map area is accessible from State Highway 20, and several section line, dirt roads which run east-west and end at an elevation of about 6200 ft. The western and northern portion of the map area are accessible from a dirt road located about 2 miles west of Devils Gate, which heads north off of U.S. Highway 50. Several less traveled dirt roads and jeep trails take off from the road and head for the mountain; most end at an elevation of about 6600 ft.

Methods of Study

The field work was done during the summers of 1980 and 1981. Map stations and contacts were plotted on an enlargement of the U.S. Geol. Surv. topographical map of the Whistler Mountain quadrangle. Geophysical stations were established at approximately 0.2 mile intervals using a fluxgate magnetometer. Over 250 specimens were collected, of these 60 representative samples were selected for thin-section examination.

Previous Work

Whistler Mountain was first visited in 1859 by the United States Corps of Topographical Engineers, commanded by Captain J. H. Simpson, who were searching for a wagon route from Utah to California. The Simpson Expedition passed through Devils Gate, which they called "Swallow Canyon." Expedition geologist, Henry Englemann, recognized and collected Devonian fossils there. Meek (1876) later identified and described fossils.

Clarence King visited the area in 1869, during the geological exploration of the Fortieth Parallel. King, the

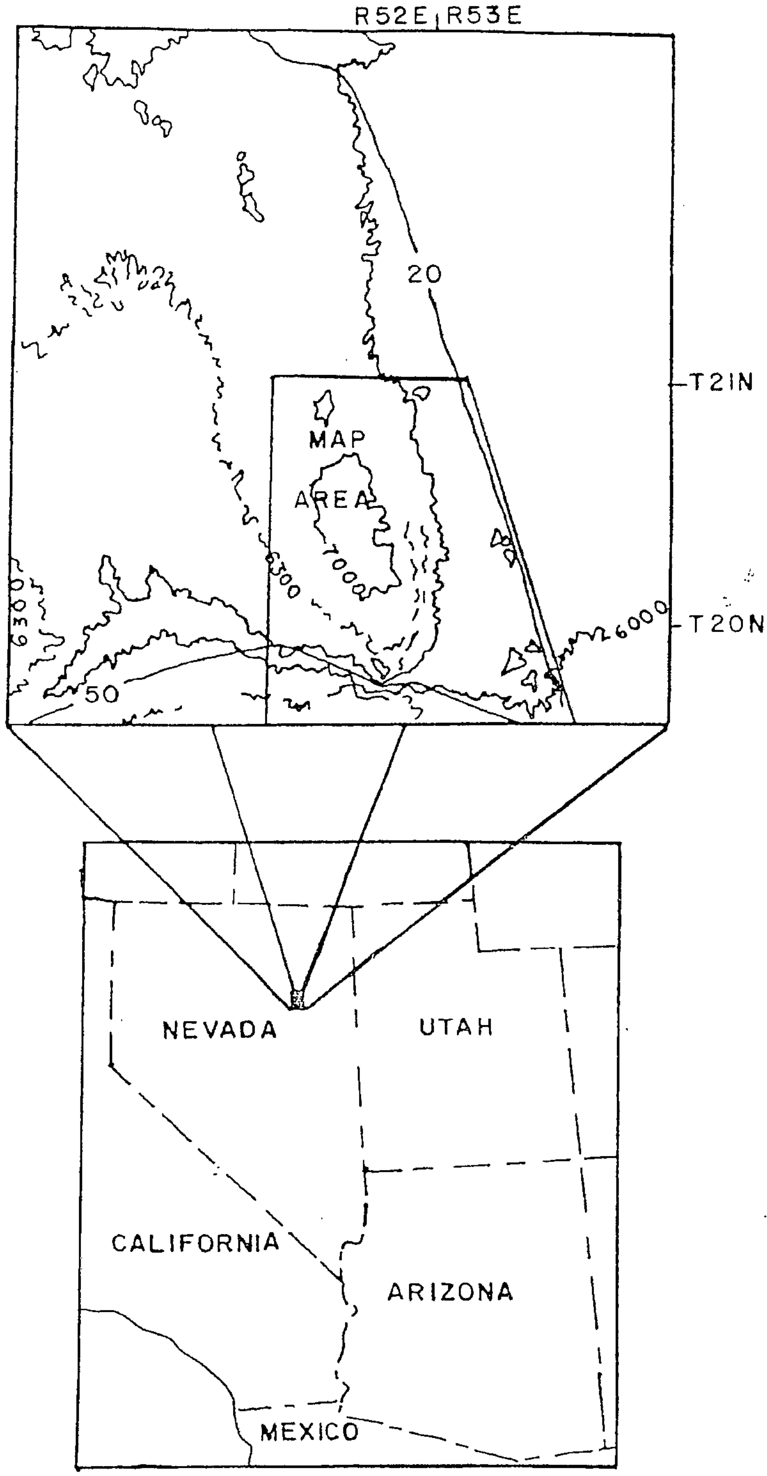

Fig. 1. Index map showing location of Whistler Mountain, Eureka County, Nevada.

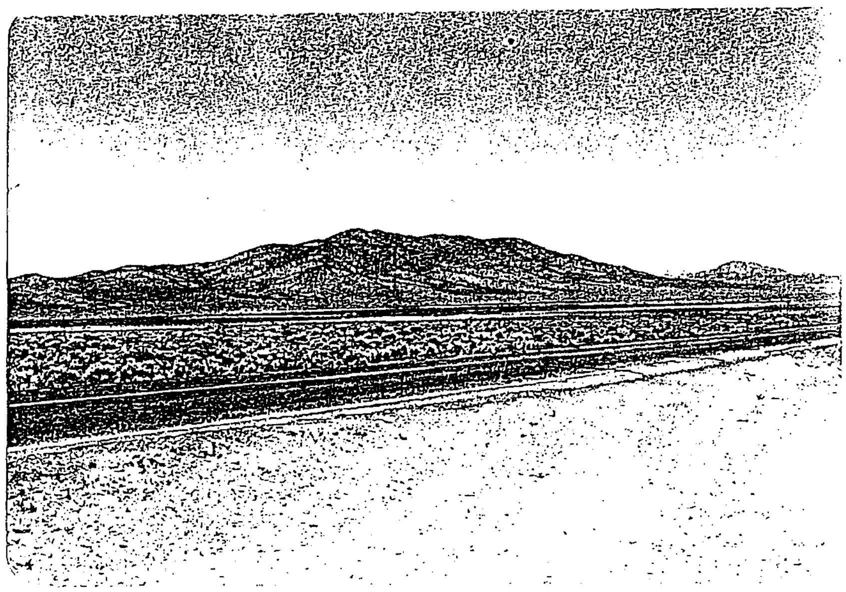

Fig. 2. Whistler Mountain, Nevada. Looking northwest.

leader of the exploration, considered the ranges to be a series of eroded folds (1870).

Detailed geologic work began with Arnold Hague in 1880. Hague, assisted by Walcott and Iddings, centered his attentions on the Eureka mining district. During his work in Eureka, Hague visited numerous nearby areas. He set the framework for future geologic work by defining such formations as: the Eureka quartzite, Lone Mountain limestone, and Nevada limestone (Hague, 1892). Walcott's study of the paleontology of the Eureka area was published in 1884.

Pleistocene lakes in the Great Basin received attention almost from the start of exploration. Gilbert began his studies of the Great Basin in the geographical and geological surveys West of the 100th Meridian (1874, 1875). His work on Pleistocene Lake Bonneville (1890), remains a classic today. Russell (1885) also contributed much to the knowledge of Pleistocene lakes with his work on Lake Lahontan. Meinzer (1922) continued this tradition by compiling a map of known and newly discovered Pleistocene lakes of the Great Basin.

Nolan began his study of the Great Basin in 1928 and proposed the existence of a Paleozoic positive area during the late Devonian. His studies of the Great Basin continued during the 1930's, and his 1943 report summarized and described much of the geology. Cooperating with Merriam and Williams, Nolan (1956) produced a comprehensive report of the stratigraphy at Eureka. This report has now become a standard. A geologic map of the Eureka district, scale 1:12,000 was published by Nolan and others in 1959. In 1962, Nolan produced a comprehensive report of the mining district, which also described part of the town's heritage.

During the 1930's, Merriam began a study of the Devonian rocks in the Roberts Mountains. His 1940 report on the stratigraphy and paleontology of the Roberts Mountains region, resulted in the restricting and redefining of many of Hague's original formations. This 1940 report also included a stratigraphic section at Devils Gate and a geologic map of the Whistler Mountain area. In 1942 Merriam and Anderson published another report of the Roberts Mountains region and recognized the existence of the Roberts Mountains thrust. The 1942 publication also revised their map of the geology of the area north of U.S. Highway 50.

Brew (1961a, b) produced two preliminary reports on the Mississippian stratigraphy and described a new thrust fault in the Diamond Mountains. In 1971, Brew continued his Mississippian studies, and proposed a type section for the Diamond Peak Formation. He recognized eight members in the Diamond Peak Formation and two informal facies for the Chainman Formation in the Diamond Mountains.

Roberts has done extensive work on mineral belts and Paleozoic rocks of Nevada. A 1960 paper summarizes this work and suggests that the alignment of mineral districts in Nevada is related to thrusting. Roberts and others started field work in the Eureka district in 1952. The results of their study were published in 1967 in Nevada Bureau of Mines Bulletin 64.

K-Ar dating methods were used by Armstrong (1966) to date Whistler Mountain at 165 (+25 to -8) million years. Later Armstrong redated Whistler Mountain as 152 (±3) million years old. Blake and others (1975) dated several ignimbrites in the Eureka area as Oligocene to very Early Miocene.

GEOMORPHOLOGY

Regional Geomorphology

The Great Basin, in which Whistler Mountain is located, is the northern subdivision of the Basin and Range Province (Fenneman, 1931). The name, Great Basin, was applied in 1844 by J. C. Fremont, who noted that no water flows from it into the sea. The area of the province is about equally divided between the mountains and basins. The ranges trend approximately north-south to a little east of north, and are generally parallel to one another. Ranges differ in length, but are usually between 50 to 70 miles long, and 6 to 15 miles wide. Typical mountain elevations are 7-10,000 feet above sea level. The contact between mountain flanks and valley floor is marked by a distinctive slope change. Ravines and deeply-incised, V-shaped valleys are common. These valleys frequently give way to extensive alluvial fans upon emergence from the mountains. Desert pavement and desert varnish are quite common on valley floors and outcrops, respectively.

Oligocene and Miocene block faulting and tilting, produced many of the present day basins and ranges. Faulting continues today, throughout much of the Great Basin. The initial rise of the Sierra Nevada in late Miocene time, coupled with block faulting, isolated the Great Basin. Individual basins within the Great Basin are filled with thick accumulation of Miocene-Pliocene sediment. Quaternary sediments consist chiefly of lake beds and fanglomerates, but locally glacial deposits and river gravel and silt are well developed (Nolan, 1943).

The semiarid to arid climate of the Great Basin, is produced by the rain shadow effect of intervening mountains. Mountains such as the Sierra Nevada, remove much of the moisture from the eastward moving air masses of the Pacific Ocean. Rainfall is influenced by orography, precipitation generally increases with increasing altitude. The southern half of the Great Basin receives the least rainfall and has the highest temperature (Fenneman, 1931; Wright and others, 1965).

Local Climate

Eureka's climate is typical of the northern Great Basin, with average July temperatures ranging from 65°F to 75°F in the lower valleys, becoming cooler with increasing elevation. However, days with maxima over 90°F are frequent in July and August. Winter temperatures average between 20°F and 30°F in the valleys, although minima as low as -40°F do occur. The average rainfall is 10 to 15 in. The soils are "northern gray desert. Vegetation is sage brush (Artemisia, spp.), with pinon (Pinus monophylla) and juniper (Juniperas spp.) on the mountain slopes and greasewood (Sarcobatus vermiculatus) on the salt flats. Other plants includes rabbit brush (Chrysothamnus spp.), white sage (Eurotia lanata), and mountain mahogany (Cercocarpus ledifolius)

(Roberts and others, 1967).

Local Geomorphology

Whistler Mountain is the southern most portion of the north-south-trending Sulphur Springs Range. Whistler Mountain is approximately 2 miles wide and 6 miles long. It is 8147 ft high and consists of a very fine-grained, resistant, quartz-monzonite. It is more resistant than the surrounding rocks and is bounded by steep, high flanks and cut by deep V-shaped valleys.

The Paleozoic sedimentary rocks in Diamond Valley are generally overlain by 7,000 ft or more of unconsolidated Tertiary sediments. The cherty Vinini Formation occurs as abrupt ridges and hills, whereas the shales constitute low rounded hills. Sandstones and shales of the Mississippian rocks commonly occur as small ridges and rounded hills. The massive, dense, homogeneous Devils Gate Limestone forms large prominent cliffs, ridges, and peaks. Despite intense faulting and brecciation, the Eureka Quartzite forms fairly large, steep hills in Diamond Valley and near Devils Gate.

Quaternary silts, sands, and gravels of Pleistocene lakes, as well as local periglacial features and playa deposits are present.

Pediments

Whistler Mountain is nearly surrounded by a fringing erosional surface of low relief that is partially covered by a veneer of alluvium. Such surfaces are termed pediments (Hadley, 1967).

The Whistler Mountain pediment is cut across Paleozoic sedimentary rocks that include conglomeratic sands of Mississippian age, chert and shale of the Vinini Formation, and the Devils Gate Limestone. It extends, on the western flank (fig. 3), from the base of Whistler Mountain to 6400 ft; and on the eastern flank, to an altitude of about 6000 ft. The surfaces are only slightly dissected by ephemeral streams.

Pediment gravels consist of poorly-sorted, unconsolidated and slightly consolidated alluvial sediment that was mapped as older alluvium (plate 1). The gravels, which are dissected by ephemeral stream channels on the western flank, stand over 100 ft above the present valley floor. The bedrock surface of the pediment is buried by as much as 15 ft of alluvial sediment. Dissection of the sediment probably began when the early Pleistocene lake in Kobeh Valley overflowed a col at Devils Gate and eroded a trench, which allowed it to drain into Diamond Valley thus changing the local base level (Wayne, 1982). The large ephemeral channels in section 9, 10, 15, and 16, T. 20 N., R. 52 E., are a product of this event.

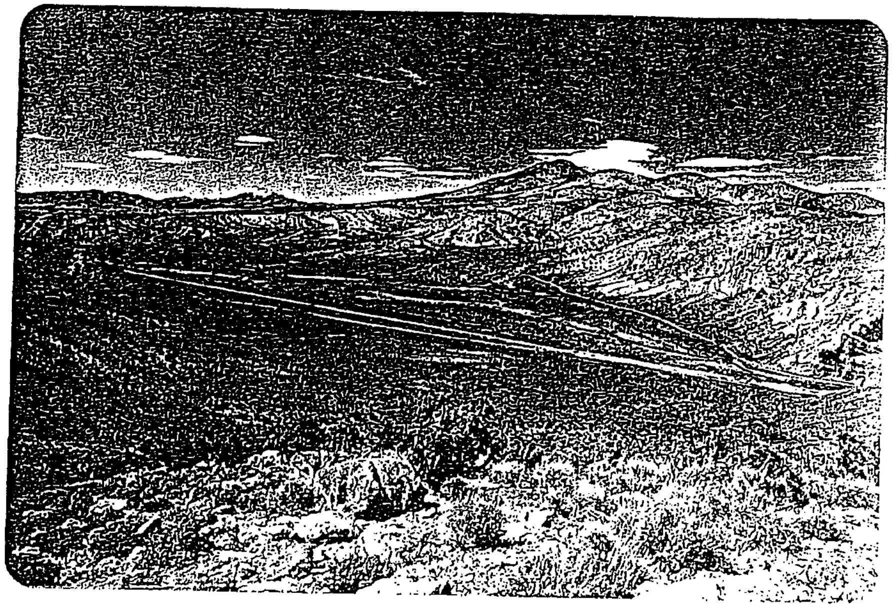

Fig. 3. Pediment surface on the western flank of Whistler Mountain. Looking north-northwest.

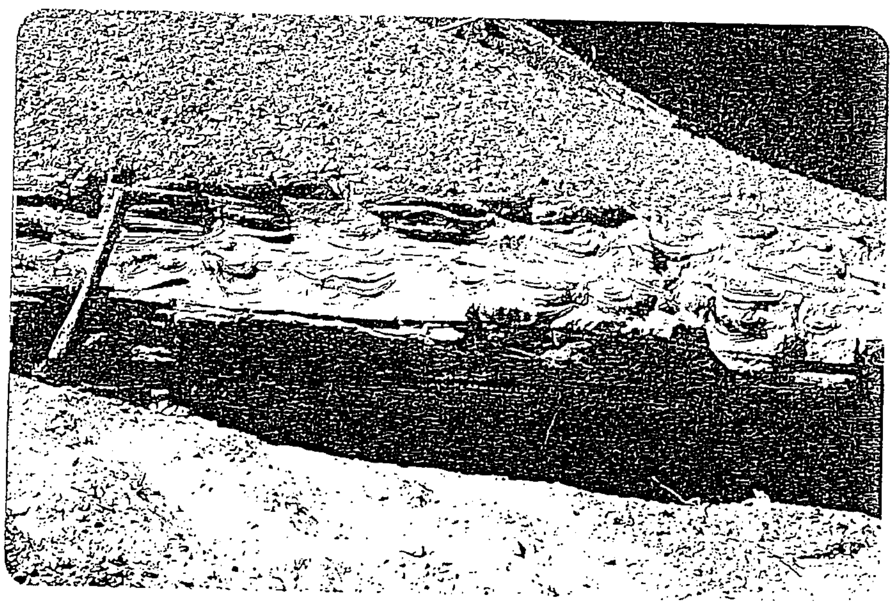

Fig. 4. Vitric tuff showing contorted bedding. Looking north.

The gravels exposed north and south of U.S. Highway 50 at Yahoo Canyon, were alluvial fans formed by streams, which drained into Kobeh Valley from the Mahogany Hills and Mountain Boy Range. These fans consist of cemented inter-bedded and noncemented beds that contain angular fragments of limestone, chert, and sandstone. Most of the beds are 2 to 3 ft thick and were extensively dissected by ephemeral streams.

Age of the pediment surface is believed to be late Miocene to early Pliocene (Wayne, 1982).

Pleistocene Climate

During the Pleistocene when it was cooler and wetter the mean annual temperature was about 5°F cooler than today, the pluvial mean annual precipitation averaged 68 percent more than current precipitation, and the mean annual pluvial lake evaporation averaged 10 percent less than it is today (Mifflin and Wheat, 1979).

Pleistocene Lakes

Kobeh and Antelope Valleys

According to Merriam and Anderson (1942) Kobeh Valley (plate 2) was once the site of a fairly large fresh water lake. They note that, "Here and there on the lower allu-viated slopes bordering Kobeh Valley are exposures of white sands and silts representing Pleistocene lake beds; in some localities as at Lone Mountain these contain abundant diatoms." Blackwelder and others (1948) confirm Merriam and Anderson's findings, and consider Diamond Valley to be part of the Lahontan system. Their field work indicates Kobeh and Antelope Valleys streams drained by arroyo channels through Devils Gate. They also report that in isolated springs of both western valleys "a form of the subgenus Apocope that is only slightly differentiated from the Lahontan subspecies" occurs. According to Wayne (1982) the lake attained a maximum height of between 6300 and 6350 ft. This determination is based upon the presence of a major spit on the northern flank of Lone Mountain (plate 2), and the pre-erosional height of the Devils Gate col.

Several large, water laid ash deposits have been found by Wayne and Rowan (1982) southeast of Lone Mountain near U.S. Highway 50 (fig. 4). The ash is a vitric tuff comprised principally of glass with trace amounts of angular to round opaque minerals. Some compaction(?) of the glass may have occurred. The tuff is vitroclastic and is very fresh (fig. 5). It is poorly consolidated, 2.0 to 2.5 ft thick, and white with some yellow staining(?). Small, 0.1 to 0.25 in, laminations are present. The tuff shows contorted bedding (fig. 6), which grades laterally into laminated wavy bedding. The contortions may be the result of slumping or be some type of flowage feature. Sediments beneath the tuff are evenly bedded and thinly laminated. Clay is present approximately 10 ft beneath the tuff (Rowan, 1982). Fission tracks

Fig. 5. Photomicrograph of vitric tuff showing vitroclastic texture.

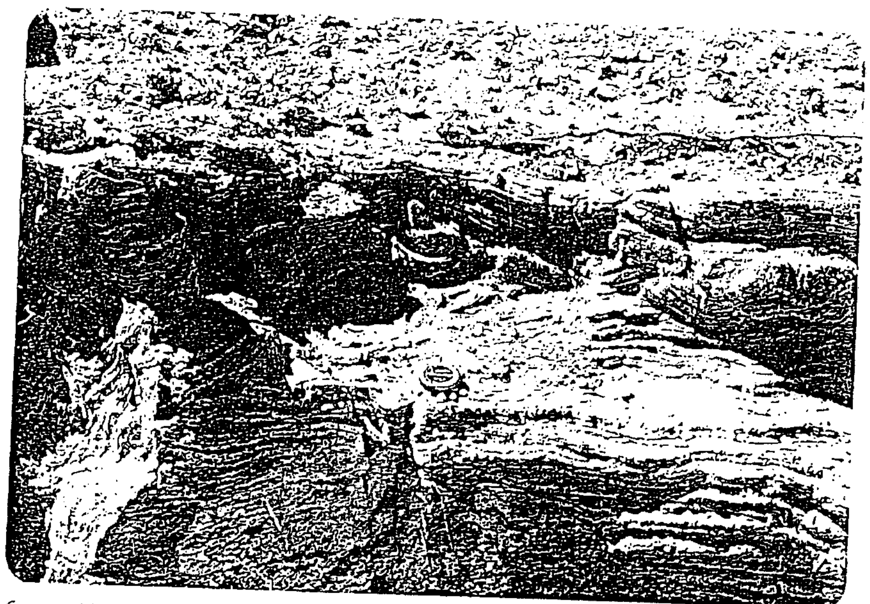

Fig. 6. Close-up view of vitric tuff showing contorted bedding. Looking north.

in glass indicate an age of 1.2 m.y. (Wayne, 1982).

Diamond Valley

This valley was the site of two, rather large Pleistocene lakes. Little is known about the oldest lake, except that it was, possibly, pre-Rye Patch (pre-Illonian) and that it attained a height of at least 6080 ft (Mifflin and Wheat, 1979). The second lake, Lake Diamond, reached an altitude of about 6000 ft and is Lahontan in age (Blackwelder and others, 1948). Springs in Diamond Valley contain several distinct forms of fish which are correlated to Lahontan fish. According to Blackwelder and others (1948) "the springs in Diamond Valley contain a distinct form of Siphateles obseus and a dace (Rhinichthys, subgenus Apocope) that is hardly different from the Lahontan subspecies."

Lake Diamond

Lake Diamond was a rather large, pluvial, closed-basin Pleistocene lake (Snyder, 1964) (plate 2). It covered an area of about 294 sq. mi, with a drainage basin area of 3,163 sq. mi. Maximum water depth was about 130 ft. The shore line stood at about 6000 ft, the elevation of Railroad Pass. If the lake level ever was higher, the lake drained through Railroad Pass and into the Lake Lahontan system.

The area just north of Eureka contains a large, old, highly dissected alluvial fan (plate 2). Its formation is related to the lowering of Lake Diamond. Beneath this fan, deltaic(?) deposits are present that show crude, coarse laminations of subangular granules. To the north, near Baily Pass in the Sulphur Springs Range, beach and terrace deposits are present. The terraces consist of alternating, unconsolidated, subrounded, well-sorted layers of silt, sand, and gravel. The coarser material is usually a light tan and reaches a thickness of 20 to 50 ft. The finer-grained material is dark brown, angular, less well-sorted, and thinner. The beach deposits consist of well-sorted clasts of carbonate and chert in gravels (Druliner, 1981).

Several shallow, gravel pits are present in Diamond Valley (plate 1). The gravels exposed in these pits are angular to subangular and very silty to silt-free. The fining upward sequence (fig. 7) in a gravel pit in the NW 1/4, section 16, T. 20 N., R. 53 E., probably represents a beach or bar deposited on the edge of Lake Diamond. The altitude of this gravel deposit is 5940 ft. The deposit, therefore, may represent a late depositional phase of the lake (fig. 8). The gravel is overlain by a thin bed of silt deposited on the playa (Wayne, 1982).

The dominant current direction along the west shore of Lake Diamond was probably southward as evidenced by head-lands and stacks (plate 2). The eastern shoreline exhibits no identifiable, erosional features (Busch, 1981). The quartzite hill in Diamond Valley, is steep at its southern end and gentler at its northern. The northern end may be a remnant spit.

Periglacial Features

Geomorphic evidence of a former periglacial environment abounds at Whistler Mountain, in the form of frost-heaved blocks, frost wedging, rock streams, and stone stripes.

Frost-heaved blocks are present only locally at the southern end of Whistler Mountain. A block in this area, which measures about 3 ft x 3 ft x 8 ft, has been heaved upward about 3 ft. Despite its upward movement, this large block is still firmly held by the surrounding bedrock. The upward movement occurs along joints where water was able to filter in. According to Washburn (1980), "frost heaving is associated with the active layer above permafrost or with seasonally frozen ground."

Frost wedging occurs most commonly on well-exposed outcrops, where small, 1 to 3 in, joints in the quartz-monzonite are common. This process produces coarse, angular, rock fragments, which become talus. According to French (1976) the most important environmental factor in an area of frost wedging is the presence of moisture. Rocks in an environment characterized by abundant moisture disintegrated faster than rocks from an area characterized by less moisture. The second most important influence is the nature of the rock involved. Igneous rocks are the most resistant and shales the least resistant to freeze-thaw cycles.

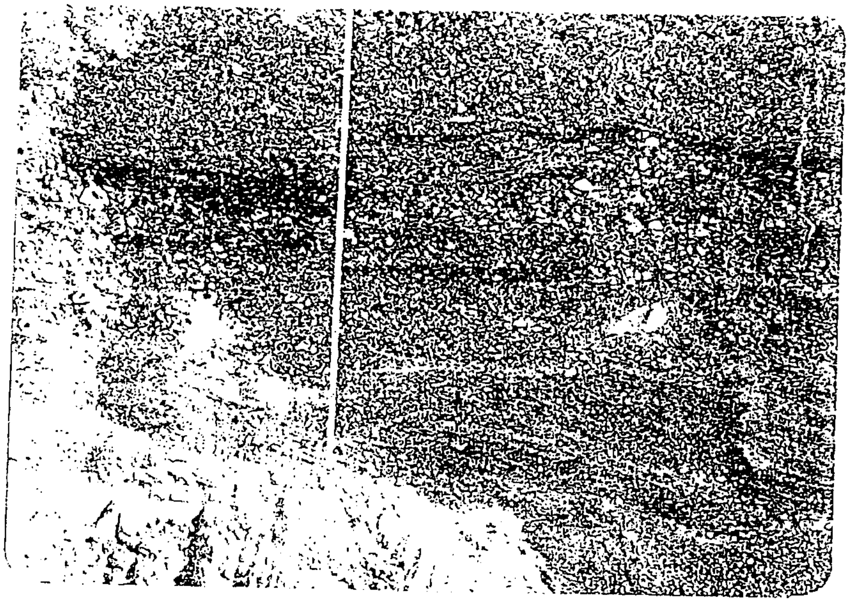

Fig. 7. Gravel pit showing sorted layers of subrounded gravels of aplite, chert, and sand size quartz grains. Looking north.

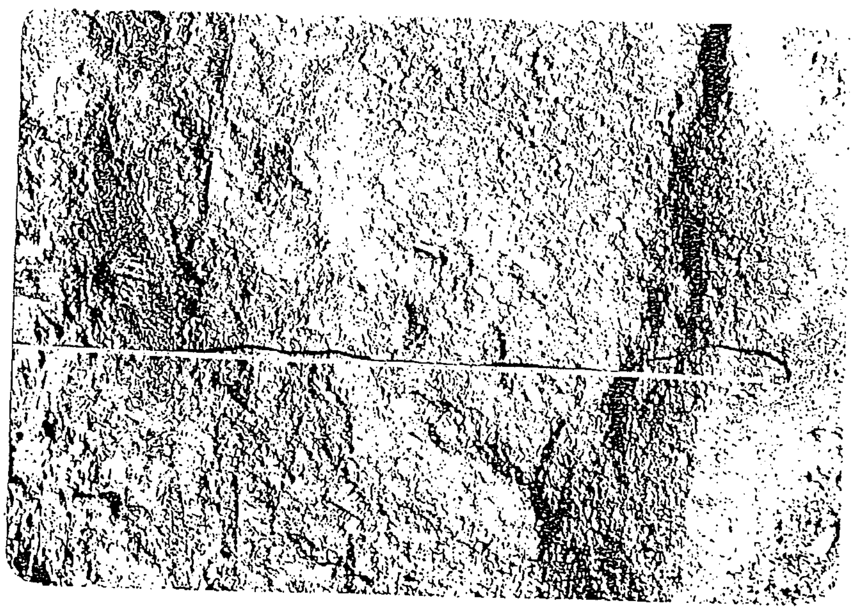

Fig. 8. Gravel pit in sec. 30, T. 21 N., R. 53 E., consists dominantly of silt and sand size material of fluvial nature. Looking west.

Abundant rock streams are present on Whistler Mountain (fig. 9). They are similar to each other, but differ from each other in terms of stream size, clast size, and shape. Only two were examined in detail, and further study is probably needed.

Rock stream A (fig. 10) is about 100 ft long and 30 to 40 ft wide at its broadest point. It narrows at its head and foot. The rock debris which comprises the rock stream ranges from 2 in to over 2 ft in length, and averages about 8 in. The rock stream is comprised wholly of subangular to subrounded quartz-monzonite. Exposed surfaces are covered by black desert varnish. A dusky red stain is prevalent on under surfaces. Some of the rocks are weathered throughout. The larger and darker debris blocks tend to be concentrated along the center or "back bone" of the rock stream, while the smaller and lighter-stained rocks lie at the outer margins. Lichens are totally absent as is a soil matrix. Ridges and troughs are present. Troughs with a depth of 1 ft have a periodicity of 4 ft, troughs with a depth of 2 ft have a periodicity of 7 ft. The depth and periodicity of these "waves" is directly dependent upon the individual size of the debris (fig. 11).

Rock stream C is similar to rock stream A, but is 150 ft long by 75 ft wide. It is composed of subangular to subrounded quartz-monzonite, which ranges in length from 3 in to over 4 ft. The average length is about 1 ft. The

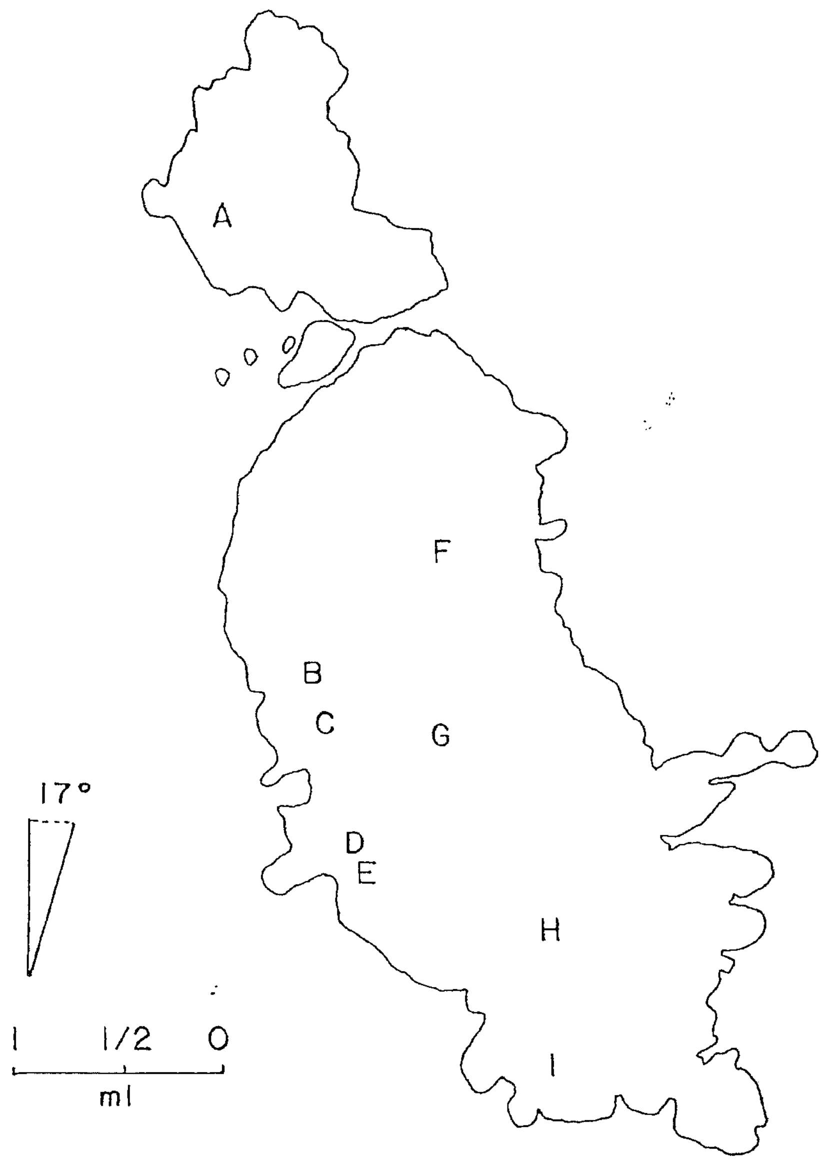

Fig. 9. Outline of Whistler Mountain showing approximate location of known rock streams.

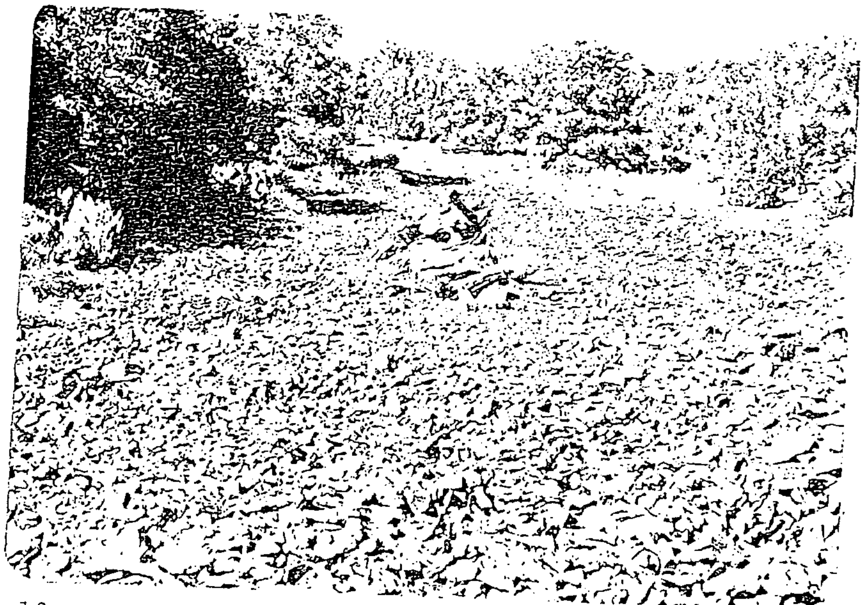

Fig. 10. Rock stream A. Note absence of vegetation, angularity of debris, and dark desert varnish. Looking east.

Fig. 11. Rock stream showing flow structure of ridges and troughs. Looking south.

upper, more exposed surfaces are once again covered by black desert varnish, whereas the less exposed surfaces are stained a dusky red. Brown to moderate brown, 2 in wide, weathering rinds are very common. The majority of the rocks are brittle and completely weathered. Larger blocks dominate the center portion of the stream. Blocks are smaller at the outer margins of the stream. Lichens and soil matrix are totally absent. Ridges and troughs are present. Troughs may be as much as 3 ft deep and have a periodicity of 12 ft. The terminus of the rock stream is 15 ft high and slopes at 29°; and an upper portion of the rock stream slopes at 15°. The head of this stream, unlike several others, is situated near some bedrock outcrops that form several minor ridges.

Movement of these rock streams under present day conditions is considered highly unlikely, as one can traverse their surfaces quite freely and safely. Any movement would require some sort of lubrication. In the Baraboo area of Wisconsin, Smith (1949) suggested that movement of individual rocks would be much easier if a "matrix of earth, or of ice, were present to provide lubrication, prevent tight contact between blocks, and transmit pressure." Solifluction is also a means of moving large blocks down slope. To obtain solifluction, a water-saturated soil is required. The melting of snow and/or ice could quite easily provide the necessary water, and a frozen subsoil would act to prevent any leakage of the water downward. In a later study, Smith

(1953) describes a block field in Pennsylvania which he says is an indicator of a former glacial or periglacial environment.

Stone stripes (fig. 12) occur along the western flank of Whistler Mountain. According to Washburn (1956) nonsorted stripes are patterned ground possessing a "striped pattern and a nonsorted appearance due to parallel lines of vegetation-covered ground and intervening stripes of relatively bare ground orientated down the steepest slope available." Movement of the stripes is dependent upon gradient, moisture, and lithology. The greatest amount of movement occurs at the center of the stripe, and decreases towards the sides and with depth. Stone stripes form as a result of mass-wasting (French, 1976).

Desert varnish is a brown to black stain or coating of ferro-manganese and clay phases which form on fine- to coarse-grained rocks of diverse structure and mineralogical composition (Knauss and Ku, 1980). This coating tends to be denser, darker, and more shiny in hollows and indentations of the surface; weathering rinds underlie the varnish. According to Perry and Adams (1978) the optically opaque or darker layers are manganese-rich and the red layers manganese-poor. However, the red layers are enriched in oxides of iron, silica, aluminum, and potassium. Experimental evidence (Allen, 1978) indicates that the source of manganese and iron comprising the varnish is external. Perry and Adams

Fig. 12. Stone stripe. Looking southwest.

(1978) postulate that windblown dust is the source and that layering in the varnish indicate cyclic deposition. Other authors (White, 1924; Laudermilk, 1931; Blackwelder, 1954), however, suggest that at least some of the varnish can be derived by organic material. Hunt (1961) has examined archeological evidence throughout the western U.S., and notes that artifacts in an arid to semiarid environment are only slightly stained after 2,000 years and older artifacts are stained darker. Moss (1951) reports that desert varnish is lacking on the most recent, historic and prehistoric glacial deposits in cirques, but is present on older ones.

The stability of the rock streams and the extent of desert varnish indicate that movement occurred a long time ago, possibly as long ago as 10,000 to 20,000 b. p.

PETROGRAPHY OF THE WHISTLER MOUNTAIN PLUTON

Introduction

The pluton consists primarily of aplitic quartz-monzonite (Williams and others, 1954; Cross and others, 1906). The border zone and associated sills are felsitic. Texturally the rocks range from poikilitic- to non-poikilitic-allotriomorphic, and microporphyritic-poikilitic- to non-poikilitic-hypidiomorphic. Boundaries between textural facies are gradational. Roof pendants, stoping, and metamorphism are absent. Flow structures are present locally on the western margin of the pluton, where it is in contact with Mississippian clastics.

The essential minerals of the quartz-monzonite are plagioclase, quartz, orthoclase, and muscovite. Accessory minerals are biotite, tourmaline, opaque minerals, zircon and apatite. Secondary minerals consist of hematite, calcite, and chlorite. Tourmaline occurs locally as disseminated spots, nodules and as a thin veneer on some joints.

Poikilitic-Allotriomorphic Facies

This facies is one of the two dominant phases of the quartz-monzonite. It forms the major portion of Whistler Mountain, being absent only at or near the borders of the pluton.

Macroscopic Description

The rocks of this facies are bluish-white, light bluish-gray, olive gray, to yellowish-gray. Weathered surfaces are pale orange, moderate reddish-brown to moderate orange pink. Locally, on exposed surfaces, rocks are stained by manganese oxide and covered with desert varnish. These rocks are very fine-grained, dense, and hard. Hand lens analysis indicates they consist primarily of muscovite, quartz, and feldspar. The muscovite occurs as small, silver-colored grains scattered throughout the rock. Quartz occurs as easily recognized phenocrysts and in the groundmass(?). The feldspar is difficult to identify and is confined to the groundmass. Tourmaline occurs locally in rocks of this facies (fig. 13). In hand specimen this rock is best termed an aplite.

Microscopic Description

Thin section examination indicates a poikilitic-allotriomorphic texture; the average grain size is between 0.1 and 0.2 mm, and that the rock consists of plagioclase, quartz, orthoclase, muscovite and accessory biotite, tourmaline, opaque minerals, zircon, apatite, and secondary chlorite. Point count analyses indicate the rock is a quartz-monzonite (tables 1-6).

Mineralogy

<u>Plagioclase</u> - Plagioclase comprises between 31.2 and 47.2 percent of the quartz-monzonite, and averages 35.1 percent.

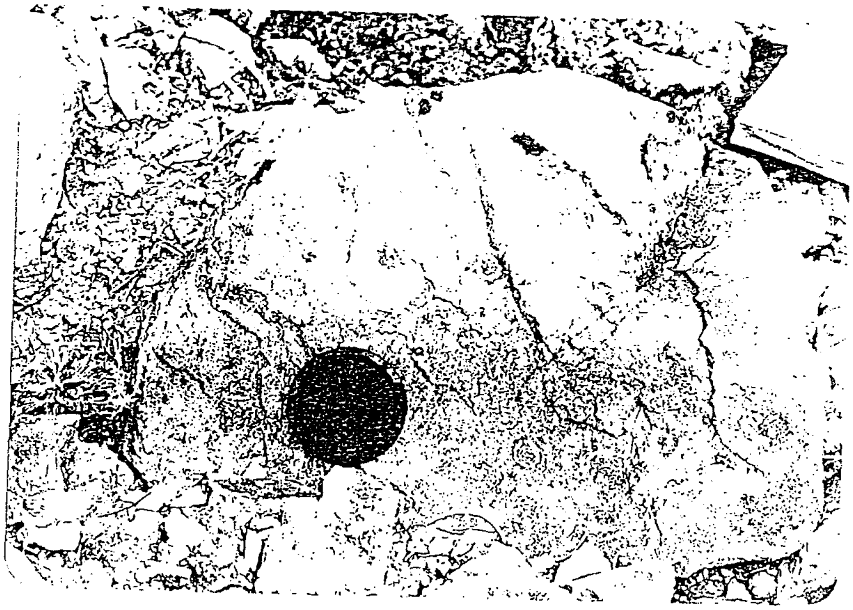

Fig. 13. Tourmaline spots. Dark tourmaline core is surrounded by a thin, spherical white halo. Contact between core and halo is sharp. In the extreme lower right corner, a tourmaline nodule is present.

Fig. 14. Photomicrograph of synneusis twins (#237). Low power (25x).

Composition of the plagioclase was determined by the Michel-Levy method and is An_{28} to An_{41}, calcic oligoclase to sodic andesine. Grains range in size from 0.01 to 0.1 mm long laths, to phenocrysts over 1.0 mm long. Albite twinning is dominant; Carlsbad, Carlsbad-albite, and pericline twining are present locally. Untwinned crystals are common. Zoning of plagioclase is rare and limited to patchy or normal zoning.

Phenocrysts are subhedral to euhedral, and often slightly corroded by impinging plagioclase laths and other phenocrysts. Synneusis twinning (fig. 14) is common among phenocrysts, and such twinning or growth frequently results in the formation of voids between attached crystals. These voids are filled by quartz or mica. The line or point of attachment is usually irregular, and marked by the presence of quartz, orthoclase, and opaque minerals. Inclusions in phenocrysts are confined to the outer margins of these crystals, and consist, commonly of quartz and opaque minerals; orthoclase is rare. Bent or broken phenocrysts are not common.

In the groundmass plagioclase occurs as laths which are generally subhedral to euhedral, and are often corroded by impinging laths. Synneusis twinning is rare. The laths commonly embay and/or occur as inclusions in quartz grains. Circular arrangements of laths occur in the larger quartz grains, and may also occur in several adjacant quartz grains

Table 1: Modal analyses of representative samples of quartz-monzonite rocks.

Sample number:	6	14	16	20	42	53
Quartz	34.0	34.0	29.6	31.2	32.6	30.2
Plagioclase	32.6	39.2	33.2	35.2	33.0	33.2
composition+	38	*--	--	--	40	39
Orthoclase	19.2	20.4	32.8	24.4	24.6	25.8
Muscovite**	14.2	6.0	4.0	8.2	9.2	9.0
Biotite	tr.	0.2	tr.	0.8	0.2	1.8
Opaques***	tr.	0.2	tr.	tr.	0.2	tr.
Zircon	tr.	tr.	--	tr.	--	tr.
Tourmaline	--	--	--	0.2	--	--
Apatite	--	--	--	--	--	--
Hematite	--	--	--	--	--	--
Sericite Pseudomorphs	--	tr.	0.4	--	0.2	--
Calcite	--	--	--	--	--	--
Epidote	--	--	--	--	--	--
Chlorite	--	--	--	--	--	--
Groundmass	--	--	--	--	--	--
Grain Size****	0.7-0.03	0.5-0.03	0.4-0.02	0.5-0.02	0.7-0.03	0.8-0.03

Description of samples:

6 - fine-grained poikilitic-allotriomorphic quartz-monzonite
14 - fine-grained poikilitic-allotriomorphic quartz-monzonite
16 - fine-grained poikilitic-allotriomorphic quartz-monzonite
20 - fine-grained poikilitic-allotriomorphic quartz-monzonite
42 - fine-grained poikilitic-allotriomorphic quartz-monzonite
53 - fine-grained poikilitic-allotriomorphic quartz-monzonite

+Composition of groundmass plagioclase.
*Unable to determine anorthite content.
**Includes primary and secondary muscovite.
***Includes only magnetite.
****Grain size measured in mm.

Table 2: Modal analyses of representative samples of quartz-monzonite rocks.

Sample Number:	59	71	75A	95	95	134
Quartz	31.0	33.6	46.0	32.4	32.4	33.4
Plagioclase	33.6	33.6	22.0	33.0	35.0	36.6
Composition	--	35	--	37	37	38
Orthoclase	26.8	28.0	--	27.4	25.6	27.0
Muscovite	7.8	7.2	11.7	6.0	6.2	7.6
Biotite	0.8	0.6	tr.	tr.	0.2	0.6
Opaques	tr.	0.4	tr.	tr.	tr.	0.2
Zircon	tr.	--	tr.	tr.	tr.	tr.
Tourmaline	tr.	--	--	--	--	tr.
Apatite	--	--	--	tr.	--	--
Hematite	--	--	--	--	tr.	--
Sericite Pseudomorphs	--	0.2	tr.	1.0	0.6	--
Calcite	--	--	--	--	--	--
Epidote	--	--	--	--	--	--
Chlorite	--	--	--	--	--	--
Groundmass	--	--	20.3	--	--	--
Grain size	0.5-0.03	1.8-0.03	1.1-0.01	0.6-0.02	0.6-0.03	0.5-0.02

Description of Samples:

59 - fine-grained poikilitic-allotriomorphic quartz-monzonite
71 - fine-grained porphyritic-poikilitic-allotriomorphic quartz-monzonite
75A - altered fine-grained porphyritic-poikilitic-allotriomorphic quartz-monzonite
95 - fine-grained poikilitic-allotriomorphic quartz-monzonite
95 - fine-grained poikilitic-allotriomorphic quartz-monzonite
134 - fine-grained poikilitic-allotriomorphic quartz-monzonite

Table 3: Modal analyses of representative samples of quartz-monzonite rocks.

Sample number:	137	146	162	163	172	173
Quartz	30.0	30.4	31.8	32.4	31.4	34.0
Plagioclase	36.6	36.0	38.8	41.6	35.0	32.0
Composition	--	--	38	28	--	--
Orthoclase	26.2	27.4	20.4	15.8	25.2	25.8
Muscovite	6.4	5.0	8.6	6.2	7.2	6.6
Biotite	0.6	0.4	tr.	1.6	0.4	1.6
Opaques	0.2	tr.	tr.	tr.	0.2	tr.
Zircon	tr.	tr.	--	--	tr.	tr.
Tourmaline	--	--	--	2.4	--	--
Apatite	--	--	--	--	tr.	tr.
Hematite	tr.	--	--	--	--	--
Sericite Pseudomorphs	tr.	0.8	--	--	0.6	--
Calcite	--	--	--	--	--	--
Epidote	tr.	--	--	--	--	--
Chlorite	--	--	--	tr.	--	--
Groundmass	--	--	--	--	--	--
Grain size	0.5-0.02	0.4-0.03	0.7-0.03	0.4-0.03	0.4-0.02	0.5-0.02

Description of Samples:

137 - fine-grained poikilitic-allotriomorphic quartz-monzonite
146 - fine-grained poikilitic-allotriomorphic quartz-monzonite
162 - fine-grained poikilitic-allotriomorphic quartz-monzonite
163 - fine-grained poikilitic-allotriomorphic granodiorite
172 - fine-grained poikilitic-allotriomorphic quartz-monzonite
173 - fine-grained poikilitic-allotriomorphic quartz-monzonite

Table 4: Modal analyses of representative samples of quartz-monzonite rocks.

Sample number:	174	182	192	197C	200A	200B
Quartz	32.6	35.2	30.2	25.8	27.8	21.4
Plagioclase	34.2	37.4	36.2	35.6	38.4	47.2
Composition	--	39	--	36	--	37
Orthoclase	25.6	17.8	26.6	33.6	30.6	25.0
Muscovite	7.4	7.4	5.8	4.8	2.8	6.2
Biotite	0.2	1.0	0.6	tr.	0.4	tr.
Opaques	tr.	1.2	0.4	tr.	tr.	tr.
Zircon	--	--	0.2	tr.	tr.	tr.
Tourmaline	--	--	tr.	--	--	--
Apatite	--	--	--	--	--	tr.
Hematite	--	--	tr.	--	--	--
Sericite Pseudomorphs	--	--	--	--	--	--
Calcite	--	--	--	--	--	--
Epidote	--	--	--	--	--	--
Chlorite	--	--	--	tr.	--	--
Groundmass	--	--	--	--	--	tr.
Grain size	0.5-0.03	0.5-0.02	0.6-0.01	0.5-0.02	0.5-0.02	0.3-0.02

Description of samples:

174 - fine-grained poikilitic-allotriomorphic quartz-monzonite
182 - fine-grained poikilitic-allotriomorphic granodiorite
192 - fine-grained poikilitic-allotriomorphic quartz-monzonite
197C - fine-grained poikilitic-allotriomorphic quartz-monzonite
200A - fine-grained poikilitic-allotriomorphic quartz-monzonite
200B - fine-grained poikilitic-allotriomorphic quartz-monzonite

Table 5: Modal analyses of representative samples of quartz-monzonite rocks.

Sample Number:	202	206	210	217	237	238
Quartz	34.8	31.8	33.6	32.8	35.2	35.2
Plagioclase	33.8	33.4	33.4	34.0	32.6	38.2
Composition	--	40	--	37	35	36
Orthoclase	23.6	27.4	24.6	26.0	26.6	21.6
Muscovite	6.2	6.0	6.6	6.6	4.6	4.4
Biotite	0.4	0.8	0.8	0.6	0.4	0.4
Opaques	tr.	0.6	0.2	tr.	tr.	0.2
Zircon	tr.	tr.	tr.	tr.	--	--
Tourmaline	--	--	tr.	tr.	0.4	--
Apatite	--	--	--	tr.	--	tr.
Hematite	tr.	--	--	tr.	--	--
Sericite Pseudomorphs	1.2	--	0.8	--	--	--
Calcite	--	--	--	--	--	--
Epidote	--	--	--	tr.	--	--
Chlorite	--	--	--	tr.	--	--
Groundmass	--	--	--	--	--	--
Grain size	0.6-0.02	0.4-0.03	0.8-0.05	0.6-0.02	0.8-0.02	1.0-0.02

Description of samples:

202 - fine-grained poikilitic-allotriomorphic quartz-monzonite
206 - fine-grained poikilitic-allotriomorphic quartz-monzonite
210 - fine-grained poikilitic-allotriomorphic quartz-monzonite
217 - fine-grained poikilitic-allotriomorphic quartz-monzonite
237 - fine-grained poikilitic-allotriomorphic quartz-monzonite
238 - fine-grained porphyritic-poikilitic-allotriomorphic quartz monzonite

Table 6: Modal analyses of representative samples of quartz-monzonite rocks.

Sample number:	259	262	263	6-4-81	Average
Quartz	32.2	35.4	34.6	33.4	31.9
Plagioclase	29.8	33.2	35.2	34.2	35.1
Composition	--	--	37	--	37
Orthoclase	33.4	26.8	22.0	26.6	25.5
Muscovite	3.0	3.8	6.0	4.8	6.3
Biotite	0.8	0.8	0.6	0.6	0.5
Opaques	0.6	tr.	1.8	tr.	0.2
Zircon	--	--	tr.	tr.	tr.
Tourmaline	--	--	tr.	--	tr.
Apatite	--	--	--	--	--
Hematite	--	--	tr.	tr.	tr.
Sericite Pseudomorphs	0.2	--	--	0.4	0.2
Calcite	--	--	--	--	--
Epidote	--	--	--	--	--
Chlorite	--	--	--	--	--
Groundmass	--	--	--	--	--
Grain size	0.6-0.05	0.6-0.02	0.6-0.02	0.4-0.02	0.7-0.02

Description of samples:

259 - fine-grained poikilitic-allotriomorphic quartz-monzonite
262 - fine-grained poikilitic-allotriomorphic quartz-monzonite
263 - fine-grained poikilitic-allotriomorphic quartz-monzonite
6-4-81- fine-grained poikilitic-allotriomorphic quartz-monzonite
average-fine-grained poikilitic-allotriomorphic quartz-monzonite

as one complete circle. Laths may be included, locally, in orthoclase.

Most of the plagioclase crystals show some sericitic alteration. A few are only flecked with sericite; a few, up to 1.2 percent, are completely replaced by sericite.

Patchy zoning (Vance, 1965) is a textural feature due to a two-stage replacement process in the magma. The sequence of development is: 1) crystallization at depth, 2) partial resorption of plagioclase due to a fall in pressure, and 3) renewed crystallization at lower pressure, necessitating the development of a more sodic plagioclase.

Synneusis twinning is not readily recognized by many igneous petrologists, despite its fairly common occurrence. According to Vance (1969) Synneusis twinning, "is the process of drifting together and mutual attachment of crystals suspended in a melt. This process is episodic, is most characteristic of the earlier stages of consolidation, and appears to be related to magmatic turbulence. Union of crystals in synneusis relation normally occurs on their broader faces in preferred orientations which coincide with positions of low interfacial energy." He also reports that "Synneusis is responsible for three major features of the magmatic fabric: 1) the small scale segregation of minerals, 2) the systematic mutual orientation of adjacent crystals in synneusis relation, and 3) the morphology of their common boundary."

The subhedral to euhedral phenocrysts, the presence of patchy zoning, synneusis twinning, and its relationship to other mineral constituents, indicate that plagioclase was the first major mineral to crystallize.

Quartz - Quartz comprises between 21.4 and 35.4 percent of the quartz-monzonite, and averages 31.9 percent. Quartz ranges in length from 0.005 to 0.7 mm and occurs as anhedral, embayed grains that average 0.12 mm in length. Quartz is dominantly poikilitic (fig. 15). The inclusions consist, primarily, of anhedral to euhedral plagioclase laths, 0.01 to 0.1 mm long, opaque minerals, 0.1 to 0.05 mm long, are fairly common; anhedral orthoclase, 0.01 to 0.05 mm long, and zircon needles 0.01 to 0.1 mm long, are less common. Locally, in the larger quartz grains, the inclusions are arranged in a roughly circular pattern. Undulatory extinction is absent. Quartz grains are often two to three times larger than normal, when they are in or near the presence of tourmaline.

The included grains, embayment by plagioclase, and anhedral shape indicate the quartz formed after plagioclase began to crystallize, but before complete crystallization of plagioclase occurred.

Orthoclase - Orthoclase comprises from 15.8 to 33.6 percent of the quartz-monzonite, and averages 25.5 percent. It ranges in length from 0.01 to 0.35 mm, and occurs generally as anhedral grains that average 0.06 mm in length. Ortho-

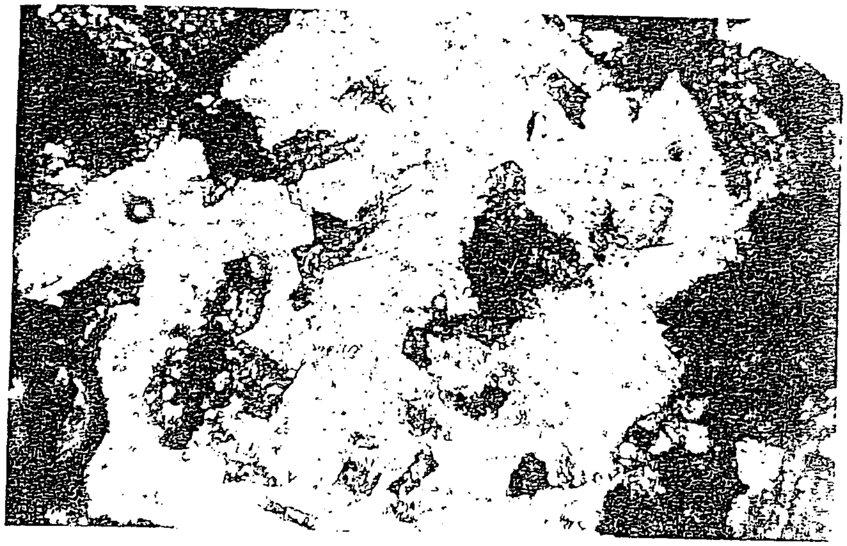

Fig. 15. Photomicrograph of poikilitic quartz showing circular arrangement of included, euhedral plagioclase laths (#173). Medium power (160x).

Fig. 16. Photomicrograph of the cryptocrystalline phase of the microporphyritic-hypidiomorphic facies. Large grains are the result of stoping of the Mississippian country rock within 5 cm of the contact zone (#12B). Low power (25x).

clase occurs as overgrowths on plagioclase and interstitially between plagioclase crystals; occasionally it will inclose one or more plagioclase laths. Orthoclase appears to be untwinned, and is occasionally replaced by quartz. Sericitic alteration is similar to that displayed by plagioclase. Some crystals were so altered that they could not be positively identified without the use of sodium cobaltinitrite as a stain. Inclusions are rare. However, when inclusions are abundant, they give orthoclase a characteristically turbid, brownish appearance. These inclusions are probably dispersed kaolin or tiny liquid inclusions of deuteric origin (Deer and others, 1963).

The anhedral shape and relationship to the other minerals, indicate that orthoclase began crystallization after plagioclase, but before quartz.

Muscovite - Muscovite is both primary and secondary in the quartz-monzonite, and represents between 2.8 and 14.2 percent of the rock, with an average of 6.3 percent. Muscovite ranges in length from less than 0.3 to over 1.0 mm, and occurs generally as subhedral grains about 0.5 mm long. Primary muscovite is occasionally molded around and/or poikilitically incloses plagioclase laths, orthoclase, quartz, and some opaque minerals. Concentrations of large muscovite grains and quartz occur locally.

Accessory Minerals - Tourmaline comprises a trace to 2.4 percent of the quartz-monzonite, and is an iron-rich schorlite. It occurs commonly as small, 0.2 mm, to large, 3.0 mm, disseminated, circular spots. The tourmaline is frequently poikilitic, inclosing plagioclase laths, and is dominantly interstitial with regard to quartz. Tourmaline is a late stage, pneumatolitic mineral.

Brown to reddish brown biotite comprises a trace to 1.8 percent of the quartz-monzonite and is generally subhedral, averaging 0.2 mm in length. Non-deformational, kink banding is present. Biotite commonly contains secondary opaque minerals which are elongate parallel to its folia, and is generally a darker brown around opaque minerals. Biotite may also be inclosed in muscovite.

Opaque minerals comprise a trace to 1.8 percent of the quartz-monzonite, and occur as blebs and/or stringlets of primary magnetite, minor hematite, and other secondary minerals which average 0.2 mm in length. Magnetite is generally confined to quartz grains. Secondary opaque minerals are found in biotite and muscovite. Manganese-oxide stain is present on some feldspars. Magnetite is a late stage mineral, and formed before quartz had completely crystallized.

Apatite and zircon are rare. The apatite occurs as anhedral to subhedral grains, about 0.05 mm long in the groundmass. Zircon occurs as subhedral to euhedral crystals, 0.01 to 0.1 mm long, primarily in groups of two to three in quartz grains. Zircon crystallized early, while apatite crystallized late.

Secondary chlorite is rare, and is the alteration product of biotite and muscovite.

Allotriomorphic Facies

This facies is the second most common phase of the quartz-monzonite. It forms a major portion of Whistler Mountain, being absent only at the borders of the pluton.

Macroscopic Description

The rocks of this facies are olive gray, light bluish-gray, light gray to white. Weathered surfaces are moderate orange pink to dark reddish brown. Locally, on exposed surfaces, rocks are stained by manganese-oxide and covered by desert varnish. These rocks are very fine-grained, dense, and hard. Hand lens analysis indicates they consist primarily of muscovite, quartz, and feldspar. The muscovite occurs as silver-colored grains scattered throughout the rocks. Quartz occurs as easily recognized phenocrysts and in the groundmass(?). Feldspar is difficult to identify and confined to the groundmass. Tourmaline occurs locally in the rocks of this facies.

Microscopic Description

Thin section examination indicates an allotriomorphic texture; the average grain size is between 0.1 and 0.2 mm long, and the rock consists of plagioclase, quartz, orthoclase, muscovite, and accessory biotite, opaque minerals, tourmaline, zircon, apatite, and secondary calcite. Point count analyses indicate the rock is a quartz-monzonite (tables 7 and 8).

Mineralogy

Plagioclase - Plagioclase comprises between 25.8 and 40.8 percent of the quartz-monzonite, and averages 34.5 percent. Composition of the plagioclase is An_{34} to An_{43}, andesine. Grains range in size from 0.01 to 0.05 mm long laths, to phenocrysts over 1.0 mm long. Albite twinning is dominant; pericline and Carlsbad-albite twinning are present locally. Untwinned crystals are common. Zoning of plagioclase is rare and limited to patchy or normal zoning.

Phenocrysts are dominantly euhedral. Minor corrosion is common and due to impinging plagioclase laths and other phenocrysts. Synneusis twinning is common. Contact boundaries are straight to very irregular, and seldom contain quartz or opaque minerals. Attachment and growth of synneusis twins create voids between crystals which are filled by quartz or mica. Joined phenocrysts not exhibiting synneusis twinning are often marked by an irregular contact which may contain quartz grains and opaque minerals. Inclusions in phenocrysts commonly consist of quartz and opaque minerals; orthoclase is rare. These inclusions are almost always confined to the outer margins of the phenocrysts.

In the groundmass andesine occurs as laths which are subhedral to euhedral, and commonly corroded by adjacent laths. Laths frequently embay quartz grains and/or occur as inclusions in the quartz. Bent or broken laths occur

Table 7: Modal analyses of representative samples of quartz-monzonite rocks.

Sample number:	89	127	143	158	185	197A
Quartz	28.8	33.8	33.0	36.8	29.8	33.2
Plagioclase	38.6	34.0	40.8	29.8	25.8	33.0
Composition	--	38	37	34	--	--
Orthoclase	23.6	22.4	19.0	25.8	43.8	28.2
Muscovite	7.0	9.8	5.8	5.2	0.6	5.2
Biotite	1.2	tr.	0.2	2.0	tr.	0.2
Opaques	tr.	tr.	0.2	0.2	tr.	tr.
Zircon	--	--	--	tr.	tr.	tr.
Tourmaline	tr.	--	--	--	--	--
Apatite	--	tr.	--	tr.	tr.	--
Hematite	--	--	tr.	--	--	--
Sericite Pseudomorphs	--	--	--	--	--	0.2
Calcite	--	tr.	--	--	--	--
Epidote	--	--	--	--	--	--
Chlorite	--	--	--	--	--	--
Groundmass	--	--	--	--	tr.	--
Grain size	1.0-0.03	0.5-0.05	0.8-0.03	0.8-0.03	0.4-0.01	0.4-0.02

Description of samples:

89 - fine-grained porphyritic-allotriomorphic quartz-monzonite
127 - fine-grained allotriomorphic quartz-monzonite
143 - fine-grained allotriomorphic granodiorite
158 - fine-grained allotriomorphic quartz-monzonite
185 - fine-grained allotriomorphic quartz-monzonite
197A - fine-grained allotriomorphic quartz-monzonite