Late Cretaceous U-Pb of a mafic intrusion from the eastern Sierra Nevada, California

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LATE CRETACEOUS U-Pb AGE OF A MAFIC INTRUSION FROM THE EASTERN SIERRA NEVADA, CALIFORNIA

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We assign a Late Cretaceous U-Pb zircon age of 97.5 Ma to a mafic pluton (here informally called the quartz diorite of Pine Lake), in the Pine Creek drainage of the Mt Tom 7.5' quadrangle of the eastern Sierra Nevada of California. Stern and others (1981) did not include the pluton in a regional compilation of the ages of granitoid rocks of the Sierra Nevada between latitudes 37° and 38°N; Bateman (1965) and Lockwood and Lydon (1975) mapped it as a separate unit. Rock unit names in this report are those currently recognized; the modal classification of each unit as recommended by the International Union of Geological Sciences (Streckheisen, 1976), if different than the recognized name, is shown parenthetically.

SAMPLING AND ANALYTICAL PROCEDURES

The sample was collected at least three meters from the nearest felsic dike; no felsic veinlets were observed in the sample in thin section. Forty kg of rock from the vicinity of Pine Lake (fig. 1) were crushed in a roller crusher. Preliminary separation using a Wilfley table and heavy liquids was followed by a warm nitric acid bath to remove any coatings on the remaining grains. Magnetic separation, followed by hand picking, yielded abundant zircon crystals which average 100 microns in size. The zircon dissolution and mass-spectrographic techniques used are similar to those of Saleeby and Sharp (1980) and Chen and Moore (1982). Decay constants are from Steiger and Jaeger (1977). The analytical data and calculated age are reported in the sample description at the end of the report.

GEOLOGY

The mafic body, composed of medium- to coarse-grained hypidiomorphic granular biotite-hornblende diorite and quartz diorite, has an outcrop area of 3 km^2. Most of the pluton is composed of biotite-hornblende quartz diorite, although biotite-hornblende diorite and hornblende gabbro are present locally. The rock is homogeneous and unfoliated almost without exception. Sharp internal contacts between rocks of differing composition or texture, as is common in other mafic plutonic rocks of inferred Late Cretaceous age in the eastern Sierra Nevada batholith (Bateman, 1965; Moore, 1963; Frost and Manhood, 1987; Ross, 1987), are rare. Representative compositions determined on samples collected from the pluton are reported in table 1.

The quartz diorite of Pine Lake is located at the intersection of three felsic granitoid plutons. The quartz diorite is intruded on the north by the granodiorite of Chickenfoot Lake (Bateman, 1965; Lockwood, 1975; Lockwood and Lydon, 1975; Frost, unpub. data). Both the quartz diorite and the granite of Chickenfoot Lake are cut by the 93.2 Ma granodiorite of Lake Edison (Stern and others, 1981; Frost, unpub. data). All rocks are intruded by the 89.8 Ma granite of Mono Recesses (Bateman, 1965; Stern and others, 1981), which is the source of spectacular near-horizontal dikes that cut all other units. The felsic dikes make up as much as 40% of the quartz diorite in the vicinity of Pine Lake.

Stern and others (1981) obtained a discordant U-Pb zircon age of 169 Ma from a heterogeneous quartz diorite to diorite pluton that intrudes the Late Triassic Wheeler Crest Quartz Monzonite (granodiorite) (Bateman, 1961, 1965) 5 km east of the quartz diorite of Pine Lake. The locality shown by Stern and others (1981) for the 169 Ma sample (their number 57) is incorrectly located on their plate 1 due to scale limitations; the correct locality is the mafic intrusive mass on the west side of the Pine Creek pendant at the Pine Creek Mine (Bateman, 1965, pl. 2) (P. C. Bateman, oral commun., 1987). Many other dated eastern Sierra Nevada mafic intrusions are also Jurassic (Sisson, 1987; Frost, unpub. data). Ross (1987) reports ages as old as Triassic (?) for sparse mafic rocks of diverse composition in the southeasternmost part of the Sierra Nevada batholith.

DISCUSSION

The Late Cretaceous age for the quartz diorite of Pine Lake reported here is the youngest published for any of the mafic intrusions of the eastern Sierra Nevada, and is younger than has been inferred for mafic intrusions based on field relationships (Rinehart and Ross, 1957, 1964; Moore, 1963; Bateman, 1965) or on age determinations made on neighboring intrusions (Stern and others, 1981; Chen and Moore, 1979, 1982; Ross, 1987). Some mafic intrusions farther south within the batholith are older than the 148 Ma Independence dike swarm (Chen and Moore, 1979, 1982; Ross, 1987; Sisson, 1987; Frost, unpub. data). These results indicate that emplacement of mafic magmas was intermittent in the region now underlain by the eastern Sierra Nevada batholith from at least the Late Jurassic through the Late Cretaceous.

Stern and others (1981) proposed that the felsic plutons that surround the quartz diorite of Pine Lake are part of a comagmatic intrusive suite similar to the Tuolumne Intrusive Suite (Calkins, 1930; Bateman and Chappell, 1979; Kistler and others, 1986). On the basis of isotopic ages, intrusive relationships, and compatibility of major-element abundance trends in the mafic and felsic plutons (table 1, see also Bateman, 1965; Lockwood, 1975), we suggest the possibility (subject to petrogenetic modeling as trace element data become available from the felsic plutons) that the quartz diorite of Pine Lake represents the earliest and least differentiated magma of the Mono Pass intrusive sequence of Stern and others (1981). The mafic intrusive mass of Hidden Lakes, at the north end of the granite of Chickenfoot Lake (fig. 2, see also Bateman, 1965) remains undated, although contact relationships indicate that it is older than the granite of Chickenfoot Lake.

ACKNOWLEDGMENTS

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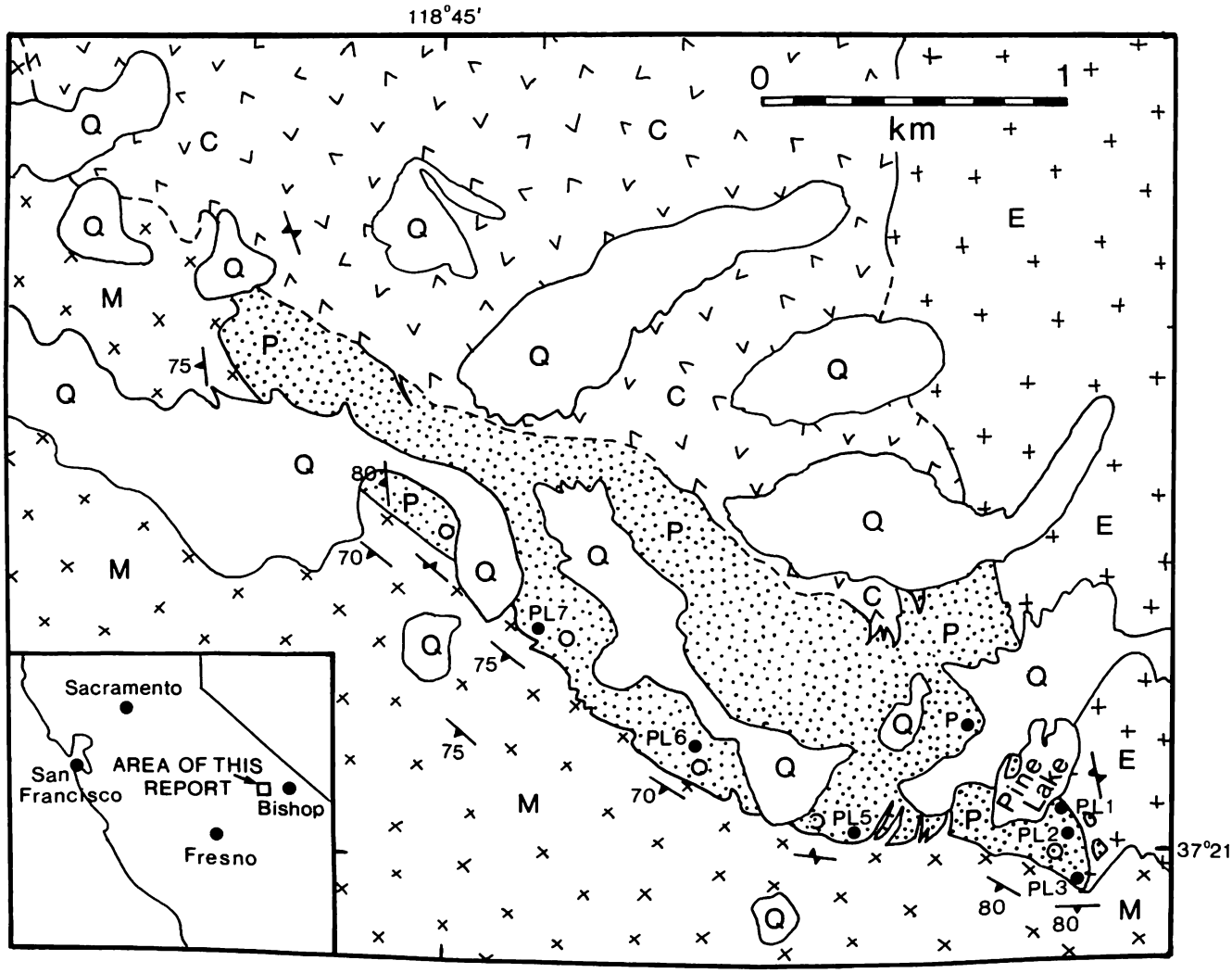

Contact, dashed where appropriate

70 Foliation, showing dip

Foliation, dip near vertical and variable

O Foliation not apparent

PL4 ● Sample locality

QUATERNARY ROCKS

Q — Till, talus, and alluvium

LATE CRETACEOUS ROCKS

M — Granite of Mono Recesses

E — Granodiorite of Lake Edison

C — Granite of Chickenfoot Lake

P — Quartz diorite of Pine Lake

FIGURE 1. Geologic map of the Pine Lake area, Mt Tom and Mt Abbot 7½′ quadrangles, California. Geology modified from Bateman (1965) and Lockwood and Lydon (1975).

TABLE 1. Selected major- and trace-element determinations, quartz diorite of Pine Lake, Sierra Nevada, California

	PL-3	PL-1B	PL-5	PL-2	PL-1C	P	PL-6	PL-7
SiO_2	49.8	53.1	53.8	54.1	55.0	57.1	57.8	58.8
TiO_2	1.25	1.03	1.08	1.01	1.00	0.99	1.00	0.94
Al_2O_3	19.3	18.8	17.5	18.7	18.3	17.2	17.5	17.0
Fe_2O_3*	10.1	8.51	8.90	8.37	8.02	8.00	7.35	6.75
MnO	0.17	0.14	0.14	0.13	0.13	0.13	0.13	0.12
MgO	4.88	3.97	4.59	3.75	3.56	3.63	3.00	2.93
CaO	9.60	8.59	8.20	8.19	7.31	6.90	6.16	5.90
Na_2O	3.29	3.25	2.95	3.40	3.22	3.30	3.70	3.64
K_2O	0.84	1.30	1.72	1.45	1.70	2.42	2.47	2.94
P_2O_5	0.40	0.29	0.34	0.28	0.30	0.27	0.32	0.30
LOI	0.38	0.82	0.55	0.68	1.37	0.12	0.50	0.62
Total	100.0	99.8	99.8	10.1	99.9	100.0	99.9	99.9
Trace elements, ppm.								
Cr	80	45	73	47	45	31	25	40
Ni	32	14	31	19	11	16	13	16
Zn	100	100	100	95	95	88	95	80
Rb	55	52	40	52	70	81	90	110
Sr	880	720	610	650	610	540	580	500
Y	12	19	20	17	20	24	28	27
Zr	47	85	135	100	135	170	190	180
Nb	8	10	12	8	12	13	16	14
Ba	400	750	950	880	860	1000	1250	1200
La	15	20	20	20	20	25	30	25
Ce	35	45	45	45	50	65	65	65

X-ray fluorescence spectroscopy by T. Frost, USGS
*Total iron reported as Fe_2O_3

were done in 1982 at the University of California at Santa Barbara by Nicholas Walker.

SAMPLE DESCRIPTION

1. *P* U-Pb

Medium-grained biotite-hornblende quartz diorite of Pine Lake (37°21'17"N, 118°43'45"W; above talus slope on NE shore of Pine Lake; Mt Tom 7½' quad, Inyo County, CA). Zircon population is homogeneous, clear, colorless, and euhedral; average size is 100 microns. A few crystals contain small, randomly oriented, irregular dark inclusions. *Analytical data:* U^{238} = 690.0 ppm, Pb^{206*} = 9.102 ppm, Pb^{208}/Pb^{206} = 0.1931, Pb^{207}/Pb^{206} = 0.05363, Pb^{204}/Pb^{206} = 0.000369, Pb^{206*}/U^{238} = 0.01524, Pb^{207*}/U^{235} = 0.1013, Pb^{207*}/Pb^{206*} = 0.04821.

(zircon) Pb^{206*}/U^{238} = 97.5 ± 0.98 Ma
Pb^{207*}/U^{235} = 98.0 ± 0.98 Ma
Pb^{207*}/Pb^{206*} = 110 ± 12 Ma

*radiogenic lead, corrected for common lead

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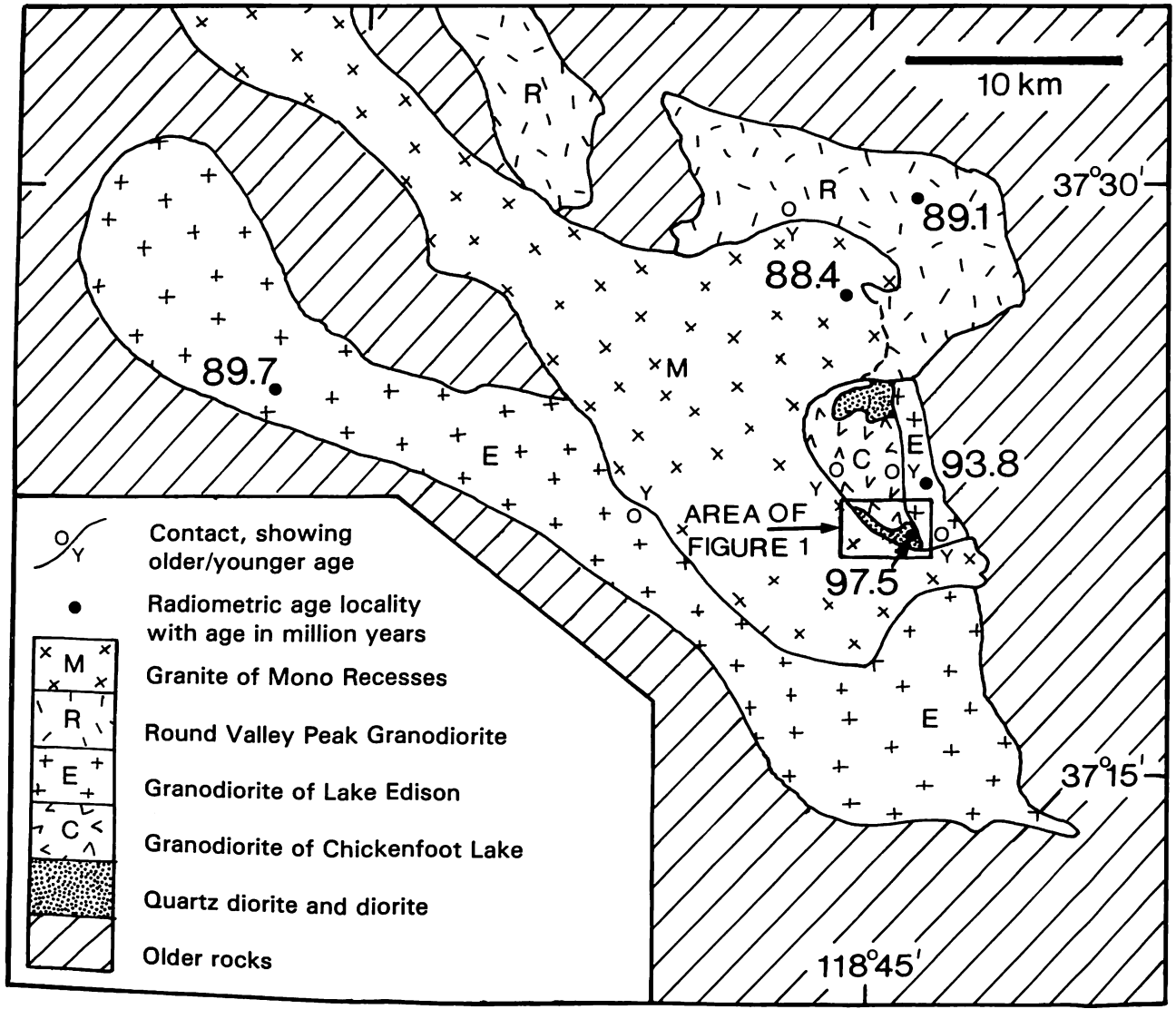

FIGURE 2. Regional age relationships, Mono Pass granitoid sequence of Stern and others (1981). U-Pb zircon isotopic ages indicated are in Ma. Ages for all but the quartz diorite of Pine Lake are from Stern and others (1981).

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