DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

FOLIO OF CHIGNIK AND SUTWIK ISLAND QUADRANGLES, ALASKA

MISCELLANEOUS FIELD STUDIES
MAP MF - 1053 - M
SHEET 2 OF 3

WILSON AND OTHERS - GEOCHRONOLOGY AND WHOLE - ROCK CHEMISTRY

Sample number	Rock type	Mineral[1]	Percent K_2O	$^{40}Ar_{rad}$/gm	Percent of $^{40}Ar_{rad}$	Age (m.y.)	Error (m.y.)	Comments
EOCENE AND OGLIOCENE INTRUSIVE ROCKS								
77AWs 30	Andesite----------	Hbl	0.317	1.666×10^{-11}	29.1	35.9	±1.03	
			.321	1.700×10^{-11}	35.2	36.7	.79	
					Mean--------	36.3	1.42	
77AWs 40	Leuco-basalt--------	Hbl	.466 .468	2.287×10^{-11}	24.2	33.7	.60	
			.467 .465	2.456×10^{-11}	36.7	36.2	.56	
					Mean--------	35.0	1.95	
77AWs 46	Andesite(?)--------	Hbl	.310 .311	1.712×10^{-11}	19.8	37.81	1.58	
			.311 .313	1.827×10^{-11}	27.8	40.31	.91	
					Mean--------	39.1	1.80	
77AWs 74	Dacite----------	Bio	8.46	4.381×10^{-10}	43.7	35.5	.64	
			8.50	4.126×10^{-10}	74.0	33.5	.59	
					Mean--------	34.5	1.60	
77AWs 122	Dacite----------	Hbl	.338 .332	1.125×10^{-11}	24.1	23.57	.59	Minimum age, possibly reset owing to proximity to Devils batholith. Impure hornblende concentrate with inclusions of plagioclase.
			.324 .323	1.009×10^{-11}	17.5	21.17	.47	
					Mean--------	22.4	1.86	
78AWs 5	Andesite----------	Plag	.483 .481	3.402×10^{-11}	45.5	48.55	.55	
			.485 .482	3.354×10^{-11}	40.4	47.64	.29	
					Mean--------	48.1	.89	
78AWs 11	Dacite----------	Hbl	.495 .487	1.381×10^{-1}	30.5	19.42	.16	Minimum age, possibly reset owing to nearby Quaternary volcanism.
			.492 .492	1.357×10^{-1}	31.0	19.08	.16	
					Mean--------	19.3	.33	
78AWs 17	Leuco-basalt--------	Hbl	.397 .405	1.911×10^{-11}	33.3	32.84	.48	
			.405 .395	2.068×10^{-11}	36.2	35.52	.51	
					Mean--------	34.2	2.02	
78AWs 24	Andesite----------	Hbl	.430 .431	2.161×10^{-11}	30.9	34.59	.55	
			.428 .430	2.020×10^{-11}	35.2	32.36	1.65	
					Mean--------	33.5	1.69	
78AWs 27	Autolith in dacite(?).	Hbl	.391 .391	2.150×10^{-11}	32.9	37.8	.32	
			.394 .387	2.019×10^{-11}	27.7	35.5	.31	
					Mean--------	36.7	1.67	
78AWs 35	Dacite----------	Hbl	.366 .365	1.800×10^{-11}	36.0	33.93	.16	
			.364 .366	1.858×10^{-11}	18.9	35.01	.33	
					Mean--------	34.5	.85	
78AWs 42	Andesite----------	Hbl	.662 .663	3.182×10^{-11}	48.7	33.08	.14	
			.663 .661	3.123×10^{-11}	46.6	32.46	.14	
					Mean--------	32.8	.48	
78AWs 43	Quartz sericite altered rock.	WR	.542 .554	2.665×10^{-11}	31.5	33.7	.54	
			.546 .534	2.691×10^{-11}	50.0	34.0	.55	
					Mean--------	33.9	.80	

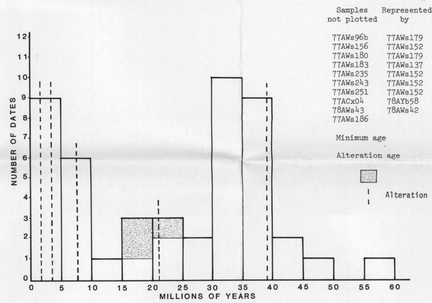
[1]Mineral abbreviations are: Bio = biotite, Chl = chlorite, Hbl = hornblende, Plag = plagioclase, WR = whole-rock.

Sample number	Rock type	Mineral	Percent K_2O	$^{40}Ar_{rad}$/gm	Percent of $^{40}Ar_{rad}$	Age (m.y.)	Error (m.y.)	Comments
LATE TERTIARY VOLCANIC ROCKS								
77AWs 9	Dacite----------	WR	1.775 1.780	2.407×10^{-11}	61.0	9.39	±0.14	
			1.772 1.780	2.336×10^{-11}	52.2	9.11	.04	
					Mean--------	9.25	.15	
77AWs 112b	Leuco-basalt------	WR	.646 .640	4.640×10^{-13}	7.99	.499	.042	
			.652 .642	5.788×10^{-13}	9.98	.623	.033	
			3.274×10^{-13}	3.87	.353	.016		
					Mean--------	.49	.15	
77AWs 134	Dacite----------	Hbl	.388	5.575×10^{-12}	4.08	9.94	.87	
			.389	5.756×10^{-12}	12.91	10.26	.21	
					Mean--------	10.10	.92	
77AWs 176	Andesite(?)-------	Hbl	.276 .276	6.249×10^{-12}	12.37	15.62	.25	Minimum age.
			.277 .278	6.969×10^{-12}	14.87	17.41	.71	
					Mean--------	16.5	1.5	
77AWs 190b	Andesite----------	Hbl	.529 .532	7.337×10^{-12}	22.92	9.56	.30	
			.535	6.433×10^{-12}	18.23	8.38	.18	
					Mean--------	8.97	.90	
77ADt 19	Andesite----------	Plag	.428 .430	9.127×10^{-12}	25.8	14.73	.09	
			.428 .429	9.866×10^{-12}	30.0	15.92	.18	
					Mean--------	15.33	.87	
78ADt 34	Andesite----------	WR	.969 1.018	9.887×10^{-13}	8.18	.685	.021	
			.992 1.001	7.911×10^{-13}	7.47	.548	.015	
			1.007 1.028		Mean--------	.62	.10	
78AYb 90	Andesite----------	WR	1.319 1.424	7.346×10^{-12}	32.15	3.69	.11	
			1.417 1.401	6.701×10^{-13}	36.72	3.37	.10	
			1.375 1.358		Mean--------	3.53	.27	
MISCELLANEOUS								
77AWs 186	Granite cobble, Chignik Formation.	Bio	6.96	9.341×10^{-10}	69.6	90.7	.54	
			7.00	9.036×10^{-10}	78.2	87.8	1.38	
					Mean--------	89.3	2.53	

Sample number	Rock type	Mineral	Percent K_2O	$^{40}Ar_{rad}$/gm	Percent of $^{40}Ar_{rad}$	Age (m.y.)	Error (m.y.)
VOLCANIC ROCKS, MESHIK FORMATION							
77AWs 102	Leuco-basalt------	WR	1.136 1.100	6.583×10^{-11}	83.3	41.01	±0.88
			1.085 1.089	6.363×10^{-11}	79.1	39.65	.85
					Mean--------	40.3	1.56
78AWs 18	Leuco-basalt------	WR	.765 .790	4.171×10^{-11}	60.7	36.91	.63
			.786 .767	4.252×10^{-11}	69.2	37.62	.64
					Mean--------	37.3	1.03
78AWs 20	Dacite----------	WR	1.395 1.374	7.089×10^{-11}	84.8	35.40	.34
			1.374 1.368	7.562×10^{-11}	72.6	37.73	.40
					Mean--------	36.6	1.73
78AWs 31	Andesite----------	WR	1.258 1.261	5.553×10^{-11}	90.5	30.35	.47
			1.265 1.257	5.505×10^{-11}	84.9	30.10	.14
					Mean--------	30.2	.49
78AWs 32	Andesite----------	WR	.981 .983	4.432×10^{-11}	67.1	31.05	.48
			.985 .983	4.332×10^{-11}	72.2	30.36	.13
					Mean--------	30.7	.70
78AWs 58	Dacite----------	WR	1.554 1.530	7.694×10^{-11}	90.6	34.32	.61
			1.557 1.530	7.748×10^{-11}	89.8	34.56	.36
					Mean--------	34.4	.73
78AWs 61	Dacite----------	WR	1.210 1.206	$6.107 \times 1-^{11}$	94.8	34.74	.16
			1.213	5.985×10^{-11}	86.4	34.05	.16
					Mean--------	34.4	.54
78AWs 98	Leuco-basalt------	WR	.201 .199	6.486×10^{-12}	20.4	22.31	.33
			.200 .203	5.826×10^{-12}	25.8	20.05	.38
					Mean--------	21.2	1.68
78AWs 111	Leuco-basalt------	WR	.957 .997	5.615×10^{-11}	65.9	39.72	.79
			.974 .957	5.449×10^{-11}	78.8	38.56	.77
					Mean--------	39.1	1.37
78AWs 134	Dacite----------	WR	1.093 1.132	4.296×10^{-11}	57.3	26.54	.55
			1.134 1.106	4.195×10^{-11}	66.6	25.92	.51
					Mean--------	26.2	.87

Sample number	Rock type	Mineral	Percent K_2O	$^{40}Ar_{rad}$/gm	Percent of $^{40}Ar_{rad}$	Age (m.y.)	Error (m.y.)
DEVILS BATHOLITH AND WARNER BAY PROSPECT							
77AWs 96b	Pegmatite---------	Potassium feldspar	14.07	1.337×10^{-10}	44.1	6.59	±0.01
			14.06	1.309×10^{-10}	51.6	6.46	.10
					Mean--------	6.53	.17
77AWs 100	Granodiorite--------	Bio	9.10 9.11	1.037×10^{-10}	37.9	7.88	.13
			9.11 9.15	1.009×10^{-10}	43.1	7.67	.12
					Mean--------	7.78	.23
		Hbl	.531 .531	7.702×10^{-12}	21.3	10.05	.18
			.530 .532	7.406×10^{-12}	27.2	9.66	.15
					Mean--------	9.86	.36
77AWs 125	Tonalite----------	Bio	8.97	7.95×10^{-11}	62.3	6.15	.09
			8.97	7.63×10^{-11}	48.7	5.90	.09
					Mean--------	6.03	.22
		Hbl	.533 .533	4.786×10^{-12}	16.0	6.25	.14
			.536	4.938×10^{-12}	12.4	6.41	.15
					Mean--------	6.33	.23
77AWs 179	Altered tonalite----	Bio	9.00 9.01	1.020×10^{-10}	4.55	7.85	.53
			9.01	9.674×10^{-11}	31.31	7.45	.27
					Mean--------	7.65	.66
77AWs 180	Pegmatite---------	Bio	9.00 9.16	9.220×10^{-11}	20.8	7.04	.17
			9.07 9.04	1.008×10^{-10}	17.1	7.71	.23
					Mean--------	7.38	.55
78AWs 95	Quartz diorite------	Bio	7.94	8.970×10^{-11}	38.8	7.85	.04
			7.91				
		Hbl	.526 .533	7.664×10^{-11}	21.1	10.08	.14
			.530				
MALLARD DUCK BAY PROSPECT							
77AWs 137	Tonalite----------	Bio/Chl	5.54 5.56	1.684×10^{-10}	20.0	20.93	.39
			5.55 5.57	1.742×10^{-10}	42.4	21.65	.38
					Mean--------	21.3	.79
77AWs 183	Quartz sericite altered rock.	WR	2.498 2.607	7.938×10^{-11}	56.3	21.81	.68
			2.487 2.462	7.475×10^{-11}	75.9	20.54	.63
					Mean--------	21.2	1.31
77AMs 1	Andesite----------	Hbl	.344	1.301×10^{-11}	29.6	26.2	.57
			.342	1.389×10^{-11}	15.3	27.9	.86
					Mean--------	27.1	1.58

Histogram of potassium-argon ages from the Chignik and Sutwik Island region



Sample number	Rock type	Mineral	Percent K_2O	$^{40}Ar_{rad}$/gm	Percent of $^{40}Ar_{rad}$	Age (m.y.)	Error (m.y.)
BEE CREEK PROSPECT							
77AWs 152	Potassically altered dacite.	Bio	8.53	4.499×10^{-11}	11.88	3.67	0.09
			8.46	4.43×10^{-11}	34.8	3.62	.07
					Mean--------	3.65	.11
77AWs 156	Quartz sericite altered rock.	WR	.947 .948	5.572×10^{-12}	21.03	4.08	.06
			.951	4.721×10^{-12}	23.74	3.45	.03
					Mean--------	3.77	.45
77AWs 215	Dacite----------	Hbl	.424 .430	1.572×10^{-13}	1.75	2.12	.12
			.433 .429	2.072×10^{-13}	2.92	2.17	.09
					Mean--------	2.15	.15
77AWs 235	Propylitically altered arkose.	Chl	.762	2.926×10^{-12}	3.41	2.65	.20
			.770	4.765×10^{-12}	7.00	4.32	.26
					Mean--------	3.49	1.23
77AWs 243	Quartz sericite altered rock.	Ser	5.44 5.45	3.111×10^{-11}	31.5	3.96	.02
			5.47	2.090×10^{-11}	38.1	3.70	.02
					Mean--------	3.83	.19
		Chl	.634 .620	3.541×10^{-12}	9.35	3.92	.048
			.625 .627				
		WR	.930 .922	4.919×10^{-12}	7.81	3.72	.09
			.912 .903				
77AWs 251	Potassically altered hybrid rock.	Bio	8.15	4.378×10^{-11}	24.11	3.73	.07
			8.16	4.229×10^{-11}	18.25	3.60	.08
					Mean--------	3.67	.10
CATHEDRAL CREEK PROSPECT							
78AWs 125	Dacite----------	Hbl	.297 .294	9.179×10^{-13}	2.83	2.16	.38
			.295	6.761×10^{-13}	1.82	1.59	.20
					Mean--------	1.88	.59
77ACx 4	Quartz sericite altered rock.	WR	1.856 1.857	3.351×10^{-12}	3.17	1.25	.04
			1.874 1.866	4.060×10^{-12}	5.56	1.51	.05
					Mean--------	1.38	.20
78AYb 57	Dacite----------	Plag	1.701 1.715	4.810×10^{-12}	22.6	1.96	.02
			1.685 1.712	4.000×10^{-12}	15.5	1.63	.05
					Mean--------	1.80	.24
78AYb 58	Andesite----------	Plag	2.097 1.098	5.272×10^{-12}	23.2	1.75	.01
			2.096	5.119×10^{-12}	12.7	1.70	.02
					Mean--------	1.72	.05
78ADt 187	Dacite----------	WR	1.454 1.411	3.535×10^{-12}	20.4	1.68	.05
			1.497 1.494	4.628×10^{-12}	8.71	2.20	.11
					Mean--------	1.94	.39

TEXT

Shown on sheets 1 and 2 are 57 potassium-argon age determinations completed as part of the mineral resource assessment of the Chignik and Sutwik Island quadrangles. In addition, 40 whole-rock chemical analyses are reported here for some of the igneous rocks that were dated.

Most of the rocks fall into two age clusters: Eocene and early Oligocene, and late Miocene and Holocene. A previous report (Wilson, 1980) discussed this bimodality in detail and related the ages to a postulated volcanic arc extant during Tolstoi and Meshik times and to the present-day Aleutian arc.

Other ages reported here indicate the timing of copper porphyry mineralization associated with the igneous activity in the region. Hydrothermal alteration is related to both episodes of igneous activity. The age determinations reported here are generally consistent with the sequence of events commonly deduced for such porphyry systems (Lowell and Guilbert, 1970); however, the events took place over longer time intervals than had been expected.

The granite cobble from the Chignik Formation (Burk, 1965) was dated for provenance studies of the Chignik to test whether a source for the Chignik was the Jurassic part of the Alaska-Aleutian Range batholith. The resulting Middle Cretaceous minimum age does not unequivocally confirm this source.

A histogram of age determinations is shown on sheet 2. Three determinations, shown in a dotted pattern, are considered minimum ages and may date rocks genetically related to the arc extant during Tolstoi and Meshik times. A short table on the histogram lists the dates that have not been included in the histogram. These determinations were not plotted because they represent the same events as samples shown on the right side of the table or because they are dates of hydrothermal alteration minerals. Dated hydrothermal alteration events are shown as dashed vertical lines on the histogram.

The chemical analyses shown on sheet 3 are approximately evenly divided between early and late Tertiary igneous rocks. Norms and other calculated parameters were calculated using the PETCAL program (Bingler and others, 1976) with modifications by Richard D. Koch. Asterisks are shown by the totals of samples that were normalized before norm calculation. For each suite A:F:M and normative Q:Or:Pl ternary diagrams are shown. Plutonic rocks have not been plotted on the normative Q:Or:Pl diagram; instead, these were named in accordance with the Streckeisen (1976) classification. Streckeisen's (1979) classification was used to name the volcanic and hypabyssal rocks. Andesitic and basaltic rock types are distinguished using a plot of percent silica versus normative color index. The A:F:M diagrams for each suite show the rocks to fall within the field of Ringwood (1977) for calcalkaline rocks. The two suites of rocks are indistinguishable on this diagram and on the normative Q:Or:Pl diagrams. Alkali-lime indices are calcic (sheet 3) for both suites (Peacock, 1931). The rocks of both suites range from leuco-basalt to dacite in composition; normative color indices are low, but many rocks that are andesitic or dacitic chemically, appear basaltic in hand sample and even in thin section. X-ray fluorescence analysis was by P. Briatow and S.R. Morgan; FeO, H_2O, and CO_2 analysis was by M.J. Cremer and S.T. Neil.

Potassium was determined using lithium metaborate fusion and flame photometry, generally following the methods of Engels and Ingamells (1970). All potassium analyses were in duplicate, and most were in quadruplicate. Paul Klock and Byron Lai were the analysts. Argon extraction and measurement were done using techniques of isotope-dilution mass spectrometry as generally described by Dalrymple and Lanphere (1969), with modifications presented by Wilson (1980). Sample preparation, argon extraction and spectrometry, and data reduction were done by the authors with assistance from Leda Beth Gray and Nora Shew. The plus-or-minus value assigned to each age is an estimate of the standard deviation of analytical precision using the method of Cox and Dalrymple (1967), together with an estimate of precision based on evaluation of the uncertainities in the concentrattion of the argon tracer and potassium measurements. Most argon extractions were done in duplicate.

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POTASSIUM - ARGON DATA

MAP AND TABLES SHOWING GEOCHRONOLOGY AND WHOLE-ROCK GEOCHEMISTRY, CHIGNIK AND SUTWIK ISLAND QUADRANGLES, ALASKA

BY

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