PRELIMINARY STUDY OF HEAVY MINERALS FROM THE BELUGA AND STERLING FORMATIONS EXPOSED NEAR HOMER, KENAI PENINSULA, ALASKA

By

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INTRODUCTION

This report describes a preliminary investigation of the usefulness of heavy minerals as an aid in the stratigraphic subdivision of the Kenai Group of Tertiary age exposed in the southern part of the Kenai Lowland near Homer, Alaska (Fig. 1). The work is based on a study of selected rock samples from measured sections along seacliffs and canyons on the north side of Kachemak Bay. Detailed descriptions of these sections and others are in a report by Adkison, Kelley, and Newman (1975). Locations of measured sections from which heavy-mineral samples were taken are shown on figure 1 and given in table 1. Measured sections 1a through 5 are designated the Homer Section, and measured sections L1 through L18 plus 6 through 12 are designated the Kachemak Section (Adkison and others, 1975). The sample numbers are field numbers, and the stratigraphic positions of the samples are shown on figure 2.

The study was directed primarily toward easily recognized variations in heavy-mineral content. Identification and tabulation of the more abundant nonopaque heavy minerals was emphasized, although each sample was checked for significant minor constituents. The results of the study are restricted by the limits of sampling. Samples are not evenly distributed stratigraphically and probably do not represent all variations in the heavy mineralogy of the rocks. Kirschner and Lyon (1973) presented the general aspects of the heavy mineralogy of the Tertiary rocks in the Cook Inlet basin. Kelley (1973) described the heavy-mineral suites of the Kenai Group in the Standard Oil Co. of Calif. No. 1 Deep Creek Unit well located about 25 miles north of Homer.

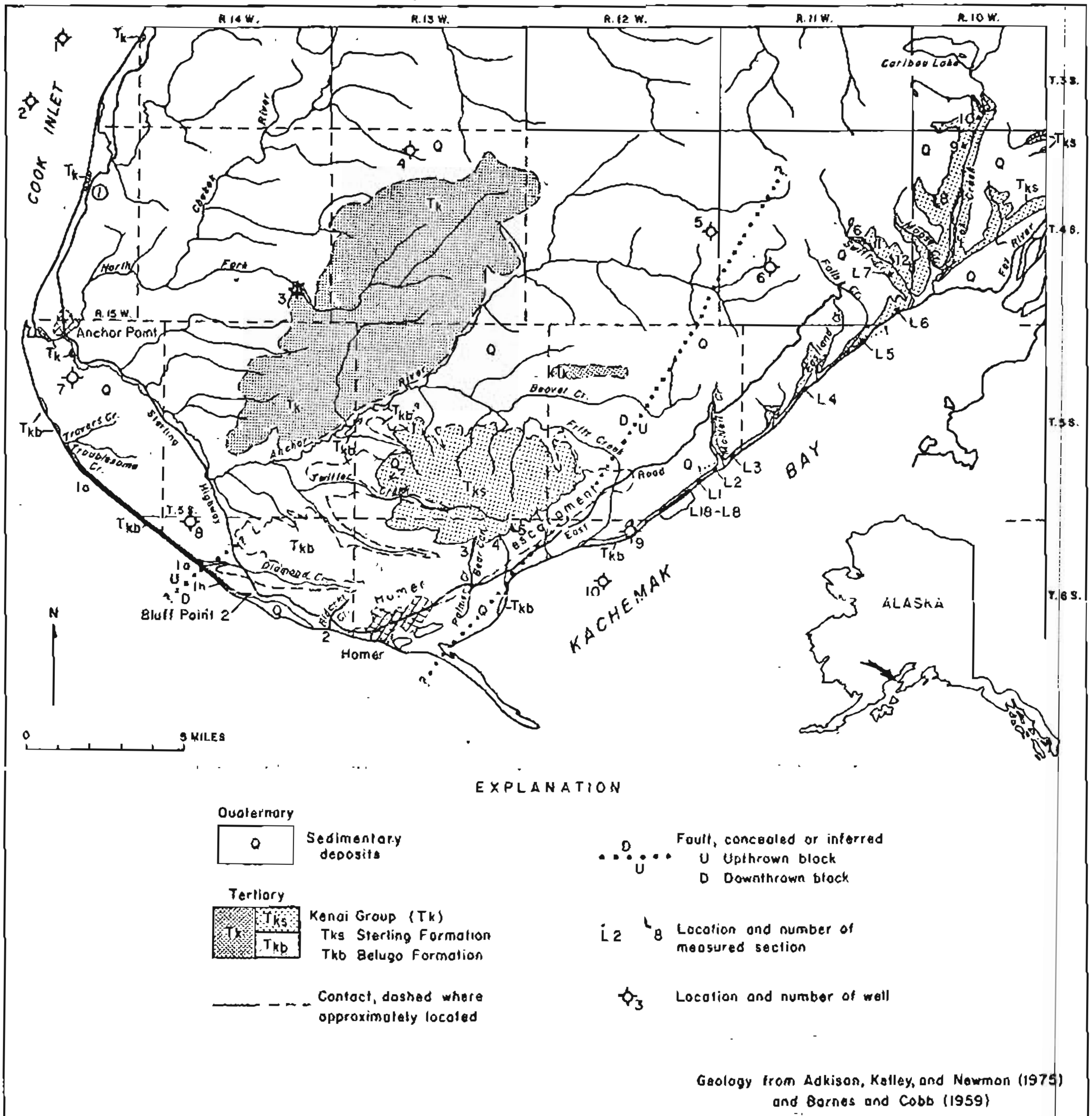

FIGURE 1. INDEX MAP SHOWING LOCATIONS OF MEASURED SECTIONS

Table 1.--Locations of measured sections.

Measured Section	Location
1a	Sea-cliff and hillside exposures along shore of Kachemak Bay from mouth of Diamond Creek, SW corner SE 1/4 NW 1/4 sec. 8, T. 6 S., R. 14 W., northwestward to a point about 0.7 mile southeast of mouth of Travers Creek (Mutnaia Gulch), NW 1/4 SE 1/4 NW 1/4 sec. 27, T. 5 S., R. 15 W., Seldovia C-5 quadrangle. This measured section includes localities 77-87 of Barnes and Cobb (1959, pl. 18). Note: Measured section 1a probably is separated from section 1b by a fault of unknown but possibly large displacement.
1b	Hillside and sea-cliff exposures below Bluff Point 2, near center NE 1/4 sec. 16, T. 6 S., R. 14 W., generally northwestward to mouth of Diamond Creek, SW corner SE 1/4 NW 1/4 sec. 8, T. 6 S., R. 14 W., Seldovia C-5 quadrangle. This measured section includes localities 88-90, and lies near locality 107, of Barnes and Cobb (1959, pl. 18).
2	Creek-bed and hillside exposures on Bidarki Creek from near cen. NE 1/4 SE 1/4 sec. 13 to sea cliff at creek mouth in SW 1/4 SE 1/4 NW 1/4 sec. 24, T. 6 S., R. 14 W., Seldovia C-5 quadrangle. This location is approximately the same as locality 117 of Barnes and Cobb (1959, pls. 18, 19).
3	Creek-bed and hillside exposures in Bear Canyon along upper part of Palmer Creek from SE 1/4 sec. 3 southward to center sec. 10, T. 6 S., R. 13 W., Seldovia C-4 quadrangle. This location is approximately the same as locality 126 of Barnes and Cobb (1959, pls. 18, 19).
4	Hillside and creek-bed exposures in large unnamed canyon about 1 mile northeast of Bear Canyon near center of sec. 2, T. 6 S., R. 13 W., Seldovia C-4 quandrangle. This location is approximately the same as locality 127 of Barnes and Cobb (1959, pls. 18, 19). The youngest beds are exposed at the head of the canyon.
5	Gully exposure in head of unnamed canyon in NE 1/4 NE 1/4 sec. 2, T. 6 S., R. 13 W., Seldovia C-4 quadrangle. Top of section is about 14 feet below canyon rim adjacent to Skyline Dirve. This location is the same as locality 128 of Barnes and Cobb (1959, pls. 18, 19).
6	Gully and hillside exposures at forks of Swift Creek in NW 1/4 SW 1/4 NE 1/4 sec. 23, T. 4 S., R. 11 W., Seldovia D-3 quadrangle. This location is approximately the same as locality 168 of Barnes and Cobb (1959, pl. 18).

Table 1 (continued).--Location of measured sections.

Measured Section	Location
7	Hillside exposure on northwest side of Fox Creek about 50-200 yards upstream from mouth of southeast flowing tributary (locally known as Danny Creek) in E 1/2 SW 1/4 NW 1/4 sec. 33, T. 3 S., R. 10 W., Seldovia D-3 quadrangle.
8	Hillside exposure in large unnamed west tributary of Fox Creek from SE corner SW 1/4 SE 1/4 sec. 7 southward to SW 1/4 NE 1/4 NE 1/4 sec. 18, T. 4 S., R. 10 W., Seldovia D-3 quadrangle. This location is approximately the same as locality 172 of Barnes and Cobb (1959, pls. 18, 19). Section starts about 15 feet below canyon rim.
9	Hillside exposure in small open canyon on west side of Fox Creek in SE 1/4 NE 1/4 sec.5,T. 4 S.,R. 10 W., Seldovia D-3 quadrangle. Measured section is about 300 feet above Fox Creek.
11	Creek-bed and hillside exposures on Swift Creek from SE 1/4 SW 1/4 NE 1/4 downstream to NW 1/4 NE 1/4 SE 1/4 sec. 23, T. 4 S., R. 11 W., Seldovia D-3 quadrangle. This location lies between localities 168 and 169 of Barnes and Cobb (1959, pls. 18, 19).
12	Hillside and creek-bed exposures in large unnamed canyon on northeast side of Swift Creek in N 1/2 SE 1/4 SW 1/4 sec. 24, T. 4 S., R. 11 W., Seldovia D-3 quandrangle. This location is approximately the same as locality 170 of Barnes and Cobb (1959, pls. 18, 19).
L3	Sea-cliff exposures northeast of McNeil Canyon in the SW 1/4 SE 1/4 sec. 24, T. 5 S., R. 12 W., Seldovia C-4 quadrangle. This locality is northeast of locality 146 of Barnes and Cobb (1959, pls. 18, 19).
L5	Sea-cliff northeast of Falls Creek in the NE 1/4 SE 1/4 sec. 3, T. 5 S., R. 11 W., Seldovia D-3 quadrangle. This is locality 161 of Barnes and Cobb (1959, pls. 18, 19).
L6	Stream-bed and canyon-wall exposures in unnamed canyon in the SE 1/4 NW 1/4 sec. 36, T. 4 S., R. 11 W., Seldovia D-3 quadrangle. This is locality 166 of Barnes and Cobb (1959, pls. 18, 19).
L10	Sea-cliff exposure in the NW 1/4 NW 1/4 sec. 35, T. 5 S., R. 12 W., Seldovia C-4 quadrangle.
L15	Sea-cliff exposures in the SW 1/4 NE 1/4 sec. 34, T. 5 S., R. 12 W., Seldovia C-4 quadrangle.

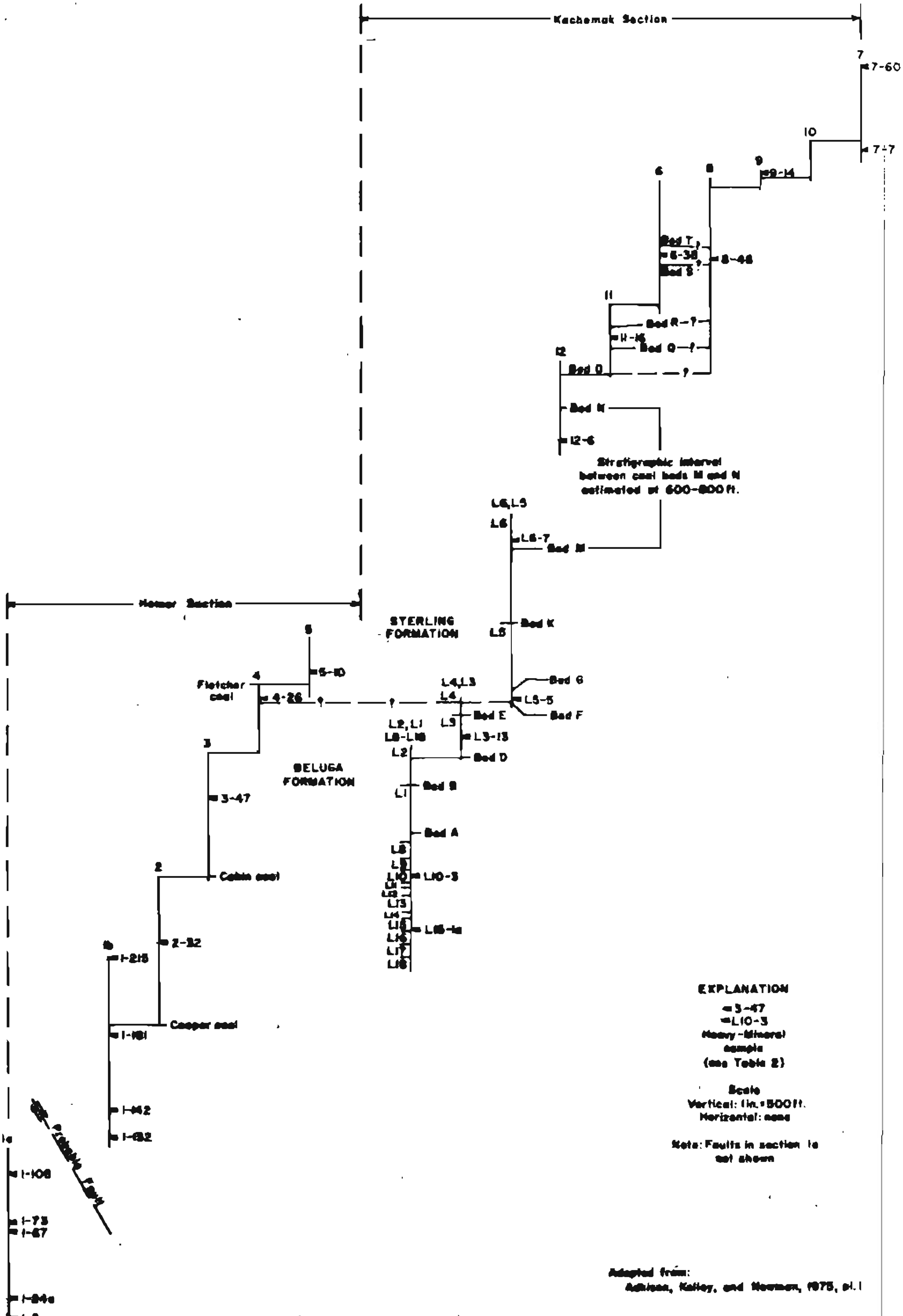

FIGURE 2. DIAGRAM OF MEASURED SECTIONS OF BELUGA AND STERLING FORMATIONS SHOWING STRATIGRAPHIC POSITIONS OF HEAVY-MINERAL SAMPLES.

The stratigraphic nomenclature for the Tertiary rocks is adapted from Calderwood and Fackler (1972) who assigned these rocks along Kachemak Bay to the Beluga and overlying Sterling Formations, the upper two formations of the Kenai Group. An isopach map by Hartman, Pessel, and McGee (1972) indicates the Sterling is absent in six wells (Nos. 1, 2, 7, 8, 9, and 10, Fig. 1) in the southern part of the Kenai Lowland; the youngest Kenai strata in these wells were assigned to the Beluga Formation. In the Kachemak Section northeast of Homer (Figs. 1 and 2), the contact between the Beluga and Sterling Formations was tentatively determined by Adkison, Kelley, and Newman (1975) using the author's heavy-mineral data and other criteria.

The work for this report was done under the cooperative agreement between the U.S. Geological Survey and the Division of Geological and Geophysical Surveys, Department of Natural Resources, State of Alaska. The writer appreciates the assistance of W. C. Fackler, former Deputy Commissioner, Department of Natural Resources, and D. C. Hartman, former State Geologist.

Procedure

Samples used in this study consisted of sandstone and siltstone. The samples were mechanically disaggregated and then sieved. The size fraction greater than 0.124 mm but less than 0.61 mm was collected for heavy-mineral separation. The sieved samples were then washed with water to remove as much clay-sized material as possible. When dry, the samples were placed in separatory flasks equipped with stop cocks. Bromoform with a specific gravity of 2.86 was used for the initial separation. The resulting heavy residues were placed in a centrifuge with a mixture of methylene iodide and bromoform having a specific gravity 3.00. Tramp iron and magnetite were removed by hand magnet.

Samples of all heavy-mineral residues were cemented to glass slides with Lakeside 70. The slides were examined quantitatively using a petrographic microscope equipped with a mechanical stage. One hundred non-opaque monomineralic grains were counted on each slide. These counts were reduced to percent abundance for each mineral and tabulated geographically from west to east (Table 2, Fig. 3).

Results

Thirteen minerals and mineral groups made up the principal constituents of the monomineralic grains. They are andalusite, apatite, chlorite, epidote, garnet, hornblende , hypersthene, monazite, siderite, sphene, staurolite, tourmaline, and zircon. Eighteen other minerals, many of which are questionably identified, occurred in minor quantities. Rock fragments were present in varying amounts in all the samples.

Most of the principal minerals in the heavy residues showed little or no alteration. Hornblende and hypersthene were generally prismatic and remarkably clear. Inclusions were common in the hypersthene crystals, and a few grains showed schiller structure. Epidote and andalusite provided exceptions to the general clearness of the minerals. The epidote was mostly turbid and packed with minute opaque inclusions. The andalusite also contained opaque inclusions and showed slight alteration to sericite. Some of the heavier minerals, such as garnet and monazite, showed pronounced rounding by abrasion during transportation. Zircon, on the other hand, was commonly euhedral.

All of the minerals except siderite appear to have been transported. Siderite occurred as small spherulitic clusters that seem to be authigenic. The significance of the siderite is unknown, although it appears to be related to the abundance of coal beds. If this is the case, it might be a useful indicator mineral for those formations rich in coal, the Tyonek and Beluga Formations.

The other minerals varied considerably in percentage from sample to sample. This is shown graphically by grouping hornblende, hypersthene, and other minerals with igneous affinities together and comparing them with the percentage of epidote, garnet, and other metamorphic minerals (Fig. 3). From this diagram, it is obvious that in some samples the epidote-garnet group is dominant, whereas in others the hornblende-hypersthene group makes up most of the sample. The variation of these two groups of minerals seems to be stratigraphically significant.

In the Kachemak Section a pronounced change in the heavy-mineral suites occurs between samples L3-13 and L5-5 (Fig. 3, table 2). Minerals of the epidote-garnet group dominate the suites in sample L3-13 and underlying samples L10-3 and L15-1a. The hornblende-hypersthene group is dominant in sample L5-5 and in most samples from overlying beds. Near the top of the Kachemak Section, two samples (9-14 and 7-7) consist mainly of the epidote-garnet group of minerals. The change in heavy-mineral suites between samples L3-13 and L5-5 was used in a broad sense in placing the contact between the Beluga and Sterling Formations in the Kachemak Section (Adkison and others, 1975).

Rocks of the Kachemak Section are separated from those of the Homer

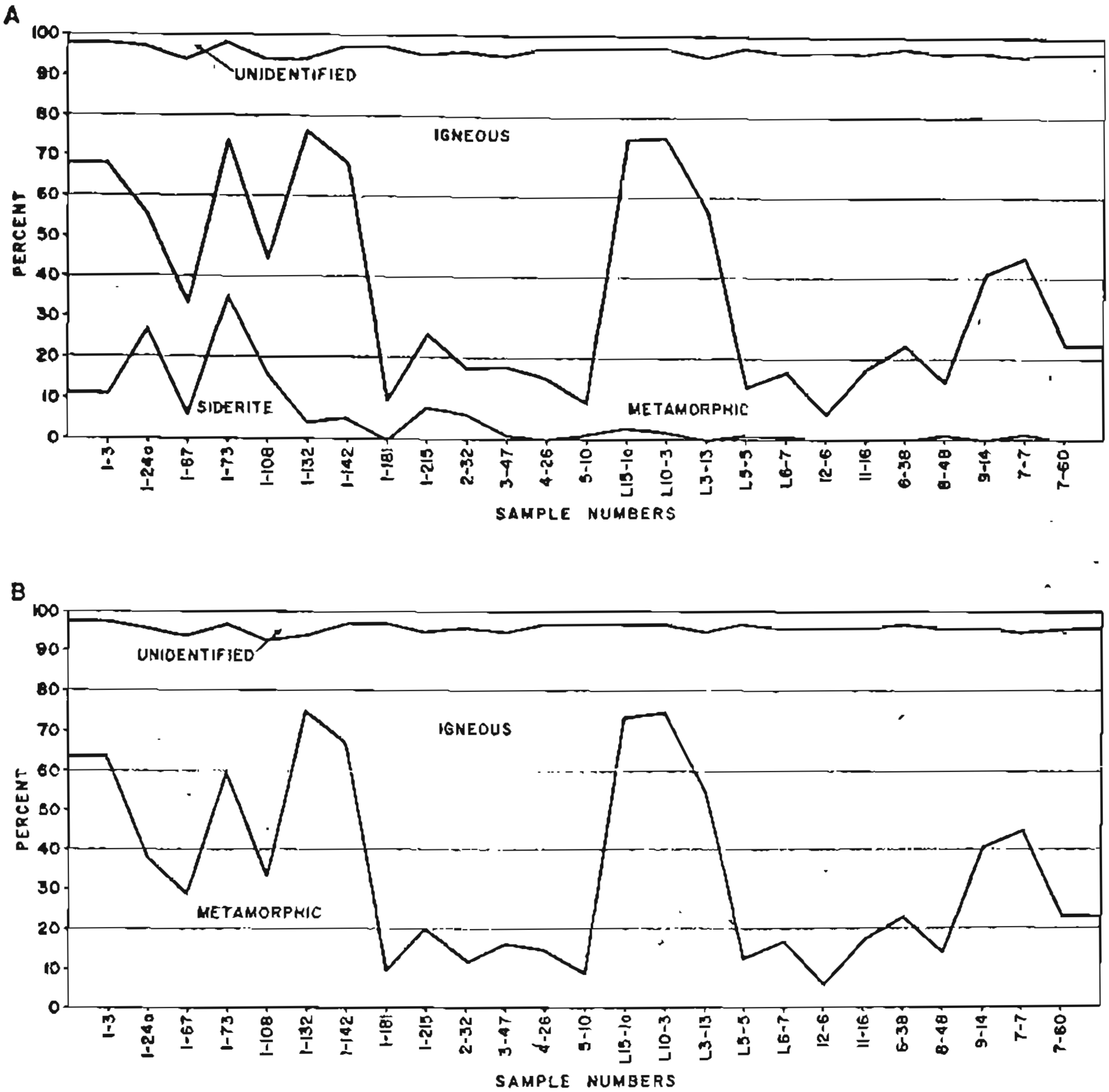

Figure 3.--Variation of heavy-mineral groups. Igneous or hornblende-hypersthene group is mainly hornblende and hypersthene but includes apatite, monazite, sphene, zircon, and rutile. Metamorphic or epidote-garnet group is mainly epidote and garnet but includes andalusite, chlorite, staurolite, tourmaline, clinozoisite, kyanite, sillimanite, tremolite, and zoisite.

Table 2. ANALYSES OF HEAVY-MINERAL SAMPLES

SAMPLE NUMBER	1-3	1-24a	1-67	1-73	1-108	1-132	1-142	1-181	1-215	2-32	3-47	4-26	5-10	L6-1a	L10-3	L11-13	L5-5	L6-7	12-5	8-16	8-36	6-40	6-14	7-7	7-60
PRINCIPAL CONSTITUENT MINERALS — PERCENT																									
ANDALUSITE	8	2	8	10	8	10	16	1	-	1	-	-	-	1	Tr.	-	-	-	-	-	1	1	4	2	-
APATITE	5	4	3	2	3	2	11	1	1	Tr.	2	Tr.	1	2	2	8	1	1	Tr.	1	1	2	10	6	1
CHLORITE	12	1	-	-	1	8	-	-	-	-	-	-	-	-	11	1	-	-	-	Tr.	-	-	1	2	
EPIDOTE	19	17	8	7	6	40	35	7	14	9	13	9	7	51	46	38	7	10	6	14	17	8	20	22	17
GARNET 1/	14	5	6	17	8	5	6	1	2	Tr.	Tr.	1	Tr.	15	12	12	2	2	Tr.	2	1	1	14	14	
HORNBLENDE	Tr.	5	14	Tr.	2	Tr.	5	57	43	56	52	42	39	6	-	5	29	36	30	49	33	47	10	15	52
HYPERSTHENE	1	4	16	-	1	2	3	24	13	19	19	30	42	7	2	5	49	35	37	24	34	23	6	8	16
MONAZITE	1	Tr.	3	-	4	2	-	Tr.	1	1	2	1	-	-	-	-	Tr.	-	-	Tr.	-	2	2	3	1
SIDERITE	11	27	8	35	16	4	5	-	8	6	1	Tr.	1	3	2	-	1	1	Tr.	-	Tr.	1	-	1	-
SPHENE	13	21	21	14	23	8	7	2	5	2	2	7	5	4	2	10	1	3	1	-	3	3	7	5	1
STAUROLITE	Tr.	1	3	-	-	3	3	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
TOURMALINE	2	1	-	1	3	Tr.	1	-	2	1	-	3	-	1	1	1	3	-	Tr.	-	2	1	-	2	1
ZIRCON	9	5	1	2	5	1	-	2	3	1	1	1	-	2	11	11	2	2	1	2	-	-	13	11	1
MINERALS PRESENT IN MINOR AMOUNTS - PERCENT																									
ALLANITE ?													1												
ANATASE ?									1		1													1	
AUGITE ?			1		2																1				
BIOTITE	1	1		4	6	2	4	2				1		3	1		1	1		Tr.		1	4	1	
CLINOZOISITE	1	1	1	1		5						2										1	2	1	1
CORUNDUM ?																		1							
CUMMINGTONITE											1														
ENSTATITE ?		Tr.																							
GLAUCOPHANE							2											1		1	1			1	2
IDOCRASE ?				1	1													1				1			
KYANITE	Tr.	Tr.			1																				
OXY-HORNBLENDE																				1					Tr.
PIGEONITE		1			2												1		1	2	2	4			1
RUTILE	2	1	2	2	2	1	1		2			Tr.	Tr.	2	3	3	Tr.	1					3		
SILLIMANITE ?	1					1																			
SPINEL																1									
TREMOLITE ?			1								1		1								1				
ZOISITE		Tr.		2				Tr.							1	5									
UNIDENTIFIABLE GRAINS — PERCENT																									
	2	3	6	2	6	6	3	3	5	4	5	3	3	3	3	5	3	4	4	4	3	4	4	5	4
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100.

Tr = TRACE

1/ INCLUDES ALMANDITE AND OTHER VARIETIES

Section by a northeast-trending lowland band, about a mile wide, that is covered by Quaternary deposits. A major concealed fault probably passes northeastward through this area (Beikman, 1974), but the displacement of the near-surface rocks is unknown. Tentative stratigraphic correlation between the Kachemak and Homer Sections, shown on figure 2, was based primarily on palynological study (Adkison and others, 1975).

In the Homer Section an upward change in the heavy-mineral suites, similar to that in the Kachemak Section, occurs in measured section 1b between samples 1-142 and 1-181 (Fig. 2). The epidote-garnet group of minerals is dominant in sample 1-142 and in samples for underlying rocks. Although faulting is probably present between measured sections 1a and 1b and within section 1a (Adkison and others, 1975), the heavy-mineral suites from these beds show no significant differences. The heavy minerals in sample 1-181 and samples from overlying rocks of the Homer Section are chiefly hornblende and hypersthene.

The change in heavy-mineral suites in the Homer Section occurs considerably lower stratigraphically than in the Kachemak Section. The lack of parallelism between the tentative palynological correlations (Adkison and others, 1975, pl. 1). and a correlation suggested by the change in heavy-mineral suites cannot be explained with the available data. In both sections the heavy-mineral samples are rather widely spaced stratigraphically, and study of more samples might show the suites change at a different stratigraphic position in either section. Additional data might indicate a laterally interfingering relationship between the two suites wherein the contact between the suites rises stratigraphically northeastward.

REFERENCES CITED

Adkison, W. L., Kelley, J. S., and Newman, K. R., 1975, Lithology and palynology of the Beluga and Sterling Formations exposed near Homer, Kenai Peninsula, Alaska: U.S. Geol. Survey Open-file Report 75-383, 239 p., 1 pl.

Barnes, F. F., and Cobb, E. H., 1959, Geology and coal resources of the Homer district, Kenai coal field, Alaska: U.S. Geol. Survey Bull. 1058-F, p. 217-260.

Beikman, H. M., compiler, 1974, Preliminary geologic map of the southeast, quandrant of Alaska: U.S. Geol. Survey Map MF 612.

Calderwood, K. W., and Fackler, W. C., 1972, Proposed stratigraphic nomenclature for Kenai Group, Cook Inlet basin, Alaska: Am. Assoc. Petroleum Geologists Bull., v. 56, no. 4, p. 739-754.

Hartman, D. C., Pessel, G. H. and McGee, D. L., July, 1972. Preliminary report on stratigraphy of Kenai Group, Upper Cook Inlet, Alaska: Div. of Geol. Survey, Dept. of Nat. Res., State of Alaska, Special Report #5.

Kelley, J. S., 1973, Preliminary study of the heavy minerals from cores of Tertiary rocks in the Deep Creek Unit well, Kenai Peninsula, Alaska: U.S. Geol. Survey Open-file Report 583, 9 p.

Kirschner, C. E., and Lyon, C. A., 1973, Stratigraphic and tectonic development of Cook Inlet petroleum province, in Arctic geology: Tulsa, Oklahoma, Am. Assoc. Petroleum Geologists Mem. 19, p. 396-407.