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# PALEONTOLOGIC DATA ON THE AGE OF THE ORCA GROUP, ALASKA

By

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## CONTENTS



## ILLUSTRATIONS



## TABLES

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The Orca Group is a widespread, very thick, and complexly deformed accretionary sequence of flysch and tholeiitic basalt in the Prince William Sound area of Alaska (Winkler, 1976; Winkler and Plafker, 1981). Despite a number of extensive field studies of the Orca Group, reliable data on the age of the unit has been exceedingly elusive. On the basis of sparse paleontologic and radiometric data, the sequence was assigned a Paleocene and early Eocene(?) age (Addicott and Plafker, 1971; Plafker and Lanphere 1974; Winkler, 1976, Winkler and Plafker, 1981). New paleontologic data suggest that some strata assigned to the Orca Group are of middle Eocene age and possibly as young as late Eocene or Oligocene. However, data suggesting an age younger than about 50 Ma appear to be incompatible with radiometrically-determined ages for plutons that intrude the Orca. This paper summarizes the published and unpublished paleontologic data from the Orca Group, considers their implications for the age of the unit, and points out the problems in age assignments.

## DISTRIBUTION AND CHARACTERISTICS

The Orca Group is exposed mainly in the Prince William Sound area, the Copper River area, and the western part of the Katalla District (Fig. 1). To the east, the sequence extends into the Bering Glacier quadrangle as a fault-bounded belt less than 10 km wide for some 85 km, and to the west correlative rocks extend to Kodiak Island and probably underlies much of the contiguous continental shelf (Plafker, 1969, 1971; Winkler and Plafker, 1981, Tysdal and Case, 1979).

The Orca Group consists mainly of feldspathic and lithofeldspathic sandstone, siltstone, and argillite turbidites with minor conglomerate deposited dominantly as a submarine fan, probably on oceanic crust (Winkler, 1976; Helwig and Emmett, 1981). Tholeiitic basalt, including pillowed basalt and basaltic breccia, and tuff intrudes and is interlayered with the flysch. Relatively thin sequences of fine-grained limestone, siliceous limestone, chert, and basaltic volcanogenic sediments that occur locally, often in association with the basaltic volcanic rocks, contain most of the microfossils recovered from the Orca Group. The thickness of the Orca Group is estimated as many thousands of meters (possibly on the order of 6,000 to 10,000 m), but accurate determinations of thickness are precluded by the pervasive tight folding and imbricate faulting together with the lack of biostratigraphic control that characterizes the sequence (Winkler and Plafker, 1981; Tysdal and Case, 1979; Helwig and Emmett, 1981).

Deformation of the Orca Group began prior to complete dewatering of the sedimentary rocks (Winkler, 1976) and soon was followed by intrusion of granodiorite, granite, and tonalite plutons, ranging in age from 50.5 to 53.5 Ma (+1.6 Ma) in eastern Prince William Sound and the area to the east (Plafker and Lanphere, 1974; Winkler and Plafker, 1981; D. L. Turner, written commun., 3/18/85; Figs. 1 and 2). Subsequently, granitoid intrusions of early Oligocene age were emplaced in the Orca Group in the western part of Prince William Sound. The Orca Group is mostly metamorphosed to the zeolite or prehnite-pumpellyite facies, although in some areas adjacent to the Eocene plutons, the rocks are locally metamorphosed to the biotite zone of the greenschist facies (Winkler and Plafker, 1981; Miller and others, 1984).

## PALEONTOLOGY

Fossils are scarce in the Orca Group. Megafossils are very rare, and those that have been found are generally not age-diagnostic. Sparse microfossils, including foraminifers, radiolarians, diatoms, silicoflagellates, coccoliths, dinoflagellates, and palynomorphs occur in hemipelagic and pelagic layers in the turbidite sequence and in volcanogenic, calcareous, and concretionary layers associated with the tholeiitic basalts, most notably on Hinchinbrook and Hawkins Islands, in the vicinity of Cordova, and at the southern end of Ragged Mountain at Cape Martin and on Fox Island (Fig. 1). They also occur in a distinctive sequence of predominantly pelagic, thin-bedded, calcareous, siliceous, and argillaceous sedimentary rocks on Montague Island near Jeanie Point, although there is some question about whether these rocks are actually part of the Orca Group (Helwig and Emmett, 1981; Dumoulin and Miller, 1984). Because all rocks in the Orca Group are hard and metamorphosed to varying degrees, microfossils from all localities tend to be poorly preserved and are rarely extractable. The only megafossils and the best-preserved siliceous microfossils are from calcareous concretions in the sequence.

Samples containing microfossils that are described herein were collected by Don J. Miller, Gary R. Winkler, and George Plafker during the course of geologic mapping projects and by Steve Nelson, Julie Dumoulin, and Marti Miller while conducting a resource appraisal of the Chugach National Forest.

### Megafossils

Age-diagnostic megafossils, including pelecypods, gastropods, and crabs, are known only from one locality at Johnston Cove in northeastern Prince William Sound along Valdez Arm (Fig. 1 and Table 1). The occurrence of the index pelecypod _Acila decisa_ Conrad indicates an age ranging from early

Paleocene to late Eocene (Addicott and Plafker, 1971). However, the assemblage also includes the gastropod Musashia (Nipponomelon) sp. cf. M. (N.) shikamai Moore (1984). According to Ellen Moore of the U. S. Geological Survey, the oldest known occurrence of M. (Nipponomelon) is in the middle Eocene in Russia; in the eastern Pacific its oldest occurrence is in the late Eocene. This suggests that the assemblage is no older than Eocene and could be as old as middle Eocene.

## Foraminifers

Localities at which the most abundant and best-preserved foraminifer faunas were collected from the Orca Group are shown on Figure 1. Numerous other samples from the Orca Group that contain sparse or poorly preserved foraminifer assemblages were not included in this study. Because it has not been possible yet to extract any of these microfossils from their hard matrix, they were studied entirely in thin section. Foraminifers and other fossil material present in the 30 thin sections studied by Gerta Keller are summarized in Table 2 and the ages of these assemblages are shown on Table 3.

The age range indicated by the foraminiferal assemblage is Paleocene through late Eocene. As shown in Table 3, the samples indicate eight general age groups as follows (zonation after Berggren and others, 1984): (1) a Paleocene(?) suite (older than 58 Ma) comprising nine samples from Hawkins Island, Cape Martin, Porcupine Point, and Hinchinbrook Island; (2) a late Paleocene to early Eocene suite (close to the Paleocene-Eocene boundary at 58 Ma) of three samples from Cape Martin, Fox Island, and Cordova; (3) an undifferentiated Paleocene or Eocene to early Oligocene suite of four samples from Jeanie Point, Fox Island, and Neck Point; (4) an early Eocene suite of probable zone P6 to P7 age based on three samples from Fox Island and Hinchinbrook Island; (5) an early to middle Eocene suite of probable zones P7 to P11 age based on one sample each from Cordova and Hinchinbrook Island; (6) a middle Eocene suite (49-53 Ma) of probable zones P11 to P12 based on three samples from Fox Island and Hinchinbrook Island; and (7) a middle to late Eocene suite based on three samples from Jeanie Point.

Fox Island samples occur in a sequence about 50 m thick ranging in age from late Paleocene to middle Eocene (73APR167B, 81ANS107B, 84APR6J, 84APR6I) with two samples of undifferentiated Paleocene to early Oligocene age (Table 3). It is therefore unlikely that the Fox Island sediments are younger than P11-P12 age, but it appears that the samples group into two suites, one latest Paleocene to early Eocene (P6-P7) and one middle Eocene (P11-P12). In this respect they are similar to the Hinchinbrook Island samples.

In eastern Prince William Sound, the Porcupine Point, Hinchinbrook Island, Hawkins Island, and Cordova samples mainly range in age from probable Paleocene to early and middle Eocene. Of the 15 dated samples from these areas, two have assigned ages that are restricted to the middle Eocene (80ANS96, 80ANS102C). Spot samples collected on Hinchinbrook Island have a wide age range including six of probable Paleocene age, one of latest Paleocene to early Eocene age, one of early to middle Eocene age, and two of middle Eocene age. This suggests an unusually long history of sedimentation for the Hinchinbrook Island sequence.

The Jeanie Point foraminifers on Montague Island are the youngest, ranging from middle to late Eocene. The age of the nearby Neck Point sample is indeterminate and could be either Paleocene or Eocene to early Oligocene.

Samples from the Cape Martin area are of probable Paleocene and Paleocene to early Eocene age based on the foraminifers.

In summary, age determinations based on planktonic foraminifers indicate that the bulk of the Orca Group bedded rocks were deposited in late Paleocene to early Eocene time (Fig. 2) and precede emplacement of the plutons. One Fox Island sample and two Hinchinbrook Island samples of P11-P12 age (Table 3) indicate deposition concurrent with, or shortly after, pluton emplacement.

The Paleocene planktonic faunas are low diversity and typically contain primarily large and small Globigerina and a few globorotalids. A late Paleocene sample from Point Martin (81ANS104B, not listed on Table 2) contains rare Nummulites suggesting a sub-tropical environment. The early to middle Eocene samples also contain tropical to subtropical faunas in both the planktonic and benthic assemblages indicating deposition in a warm water environment. Similarly, benthic assemblages in two early to middle Eocene samples (71AWK22B, 80ANS114B) contain the warm tropical to subtropical discocyclinids and lepidocyclinids along with oolites and bryozoan debris, indicating a shallow water or transported clastic assemblage.

The Orca Group has been correlated with the Ghost Rocks Formation on Kodiak Island on the basis of lithology and structural position (Plafker, 1969, 1971). The Ghost Rocks Formation contains sparse planktonic foraminifers in: (1) Two samples (AMe-76-2, AMe-76-56) collected by George W. Moore that include forms tentatively identified as the Subotina triangularis and S. triloculinoides group and Globigerina pseudobulloides Plummer or a closely related taxon, and possible Planorotalides sp. (R. Z. Poore, written commun., 10/07/76; 10/22/76). If correctly identified, these faunas suggest a Paleocene age to Poore. (2) A limestone sample (HZe) collected by William Connelly has a predominantly globigerinid fauna identified in thin section as Globigerina sp., cf. G. yeguaensis Weinzierl and Applin; G. sp., cf. G. pseudoeocaena subbotina; G. sp., cf. G. cerroazulensis (Cole); and Chilquembelina sp. that was assigned a late Eocene age and subsequently revised to probable Paleocene (Jon L. Thompson, Exxon, U.S.A., written commun.

to J. Casey Moore, U.C.S.C., 10/1/75). (3) Samples collected by Byrne (1982) containing ?Globotruncana spp. (78-KN-C8 2 and 78-KN-C8 A) and ?Racemiguembelina spp. (78-KN-C8 2) of probable Late Cretaceous age and one sample containing ?Globigerina spp. of possible early Tertiary age (R. Z. Poore, written commun. to Tim Byrne, 11/26/80). The Cretaceous fossils were recovered from limestone blocks in a structurally complex melange unit that is in fault contact with, or is unconformably overlain by, coherent strata of probable Paleocene age (Byrne, 1982). Thus, if the Cretaceous fossils are correctly identified and the samples are from the Ghost Rocks Formation rather than a pre-Tertiary formation, structural mixing or reworking is required as there is nothing else to indicate that any part of the unit is as old as pre-Tertiary. The upper age limit for the Ghost Rocks Formation is about 62 Ma (middle Paleocene) based on radiometric ages of plutons that cut the sequence (Byrne, 1982; J. C. Moore and others, 1984).

### Diatoms and silicoflagellates

A calcareous concretion collected in 1954 by Don J. Miller in the Ragged Mountains is the only sample from the Orca Group that has yielded a dateable assemblage of diatoms and silicoflagellates (Table 4). Although this assemblage was previously considered to be late Paleocene to early Eocene (John Barron in Tysdal and others, 1976), refinements in diatom stratigraphy suggest reassignment of this assemblage to the interval from late early Eocene to early late Eocene.

### Radiolarians

Radiolarian faunas were extracted by Joyce Blueford from samples collected at Cape Martin, Neck Point, and Jeanie Point (Fig. 1, Table 5). The Cape Martin fauna differs from the faunas from the other two localities and strongly resembles the Kreyenhagen and other faunas of the California

Eocene. The strongest resemblance is with the "spongy" radiolarians, i.e. Porodiscus charlestonensis, Spongodiscus pulcher, and Porodiscus circularis. Nassiallaria species are present but not as well preserved. There are a few Phormocyrtis ligulata Campbell and Clark which has a middle to late Eocene age according to Blueford's data. Also present are Nassellaria that are in the Podocyrtis group, a group which is known in the equatorial Pacific most abundantly in the Eocene. In addition, an abundance of sponge spicules and small worm tubes at Cape Martin but not at Neck Point and Jeanie Point may be suggestive of an environmental difference between the two areas. The Cape Martin assemblage is assigned a middle to late Eocene age on the basis of the presence of the middle to late Eocene species P. charlestonensis, the Podocyrtis group, which is common in the late Eocene of the equatorial Pacific, and the late Eocene to Oligocene genus Carpocanistrum.

A good fauna was extracted from one sample at Neck Point that contains abundant thick radiolarians with an inner shell considered to be Periphaena, possibly Periphaena delta. The assigned age is based on the common occurrence of the genus Periphaena in the Eocene, although if P. delta is indeed present, the age would be restricted to the early Eocene.

Three samples from Jeanie Point yielded only a few radiolarians which included a single well-preserved specimen of the age-diagnostic species Thyrosyocyrtis triacantha. T. triacantha has a range in age from the late early Eocene to the Oligocene boundary (Sanfillipo and Riedel, 1982). The associated two assemblages range in age from late Paleocene to late Eocene and early Eocene to Oligocene.

Radiolarians extracted by C. D. Blome of the U.S. Geological Survey from a calcareous concretion collected on Fox Island (84APr6K2) suggests an age assignment to the Buryella clinata radiolarian zone of early early Eocene age

(Table 5). The sample location and age range are not shown on Figures 1 and 2 because the sample was processed after these illustrations were completed.

## Coccoliths

Coccoliths were recovered by David Bukry of the U.S. Geological Survey (now with Minerals Management Service) from one sample collected at Neck Point (Fig. 1; Table 6); nine other samples were barren. According to Bukry, sample ". . . 80AWK77C has sparse overgrown specimens resembling *Coccolithus pelagicus* Wallich, *Dictyococcites bisectus* Hay et al.), and *Zygrhablithus bijugatus* Deflandre which indicate a late Eocene or Oligocene age. Owing to the sparseness and poor preservation of the specimens stratigraphic interpretation is tenuous."

## Palynomorphs

Several attempts have been made to extract palynomorphs from the Orca Group. Although palynomorphs are common in some samples, they are generally too altered for specific identifications to be made with the exception of rare grains of carbonized alder (*Alnus*) pollen from Montague Island (64APr150B) that indicate a Tertiary age (W. R. Evitt, written commun. to George Plafker, 10/11/64, 5/17/84). Helwig and Emmett (1981) noted the occurrence of a "fair" spore/pollen assemblage of Paleocene/Eocene age from a sample collected near Jeanie Point, but they did not list the species present.

## Dinoflagellates

Poorly preserved dinoflagellates were extracted from a single sample near Jeanie Point (Table 7) by Tom Agar and Lucy Edwards of the U.S. Geological Survey. According to Edwards, the age-diagnostic species *Hystrichostrogylon membraniphorum* is restricted to the early or middle Eocene, although it has been found in late Eocene strata where re-working is suspected (oral commun., 5/14/85).

## AGE OF THE ORCA GROUP

Age ranges for the fossil groups described above and for some representative Paleogene plutons intruded into the Orca Group are summarized in Figure 2.

The micropaleontologic data clearly indicate a Paleogene age for the Orca Group, with the age range constrained to Paleocene and Eocene although some fossil groups range into the Oligocene. The lower age limit of the Orca Group appears to be Paleocene based on the occurence of probable Paleocene planktonic foraminiferal assemblages in all areas where foraminifers have been found except for Jeanie Point where Eocene ages are indicated. At least some of the Paleocene assemblages are of probable late Paleocene age, but it can not be determined with available data if older Paleocene strata are present within the Orca.

Closely concordant K/Ar ages on mineral separates from discordant plutons that intruded and metamorphosed the sequence after it was deformed and accreted to the continental margin provide a firm upper age limit for the Orca Group at 50.5-53.5 + 1.6 Ma (late early and early middle Eocene). As shown in Figure 2, this upper limit is generally compatible with: (1) 26 of the 30 dated foraminifer faunas which range from Paleocene to as young as middle Eocene zone P11-P12 (49-43 Ma); (2) the one assemblage of diatoms and silicoflagellates of late early Eocene to possible early late Eocene age; (3) the radiolarian assemblages; (4) the one dinoflagellate assemblage of probable early to middle Eocene age; and (5) the megafauna which can be as old as middle Eocene. These data suggest that the younger Orca strata of middle Eocene age were deposited almost simultaneously with emplacement of the youngest dated granitic plutons.

The Jeanie Point planktonic foraminiferal assemblage is of middle to late Eocene age, but includes two samples that could not be identified more closely than Paleocene or Eocene to early Oligocene in age (80AMH2Z, 80AMH27). One dinoflagellate sample (80AMH2Z) from the same area is of probable early to middle Eocene age but could range into the late Eocene. Thus, microfossils from Jeanie Point strongly indicate an Eocene age, and are most likely restricted to middle Eocene in age.

At Neck Point poor fossil assemblages provide a tentative age of Paleocene to Eocene or early Oligocene based on planktonic foraminifers (80AWK77), Eocene, possibly early Eocene based on radiolarians (81ANS45C), and a qualified late Eocene or Oligocene age for coccoliths from one of the samples containing foraminifers (80AWK77). This meager and poorly preserved coccolith assemblage is clearly within the broad age range for the foraminifers but would be incompatible with the possible early Eocene age of the radiolarian assemblage from the same area. The age relationship of the apparently younger middle to late Eocene strata on Montague Island at Neck Point to the remainder of the Orca Group is uncertain. It could represent an overlying sedimentary sequence deposited after deformation, intrusion, and metamorphism of the Orca Group. However, there is no indication that these strata are structurally or metamorphically different from the remainder of the Orca Group (Dumoulin and Miller, 1984). If future work demonstrates that strata at Neck Point are indeed younger than the plutonism and metamorphism that affected the bulk of the Orca Group, they should be mapped as a distinct sequence that postdates the Orca Group.

## CONCLUSIONS

Paleontologic data indicate that strata presently included within the Orca Group mainly range in age from Paleocene through early and middle Eocene with possibly late Eocene to early Oligocene strata in some localities (Neck Point, Jeanie Point). Radiometric data constrain much, if not all, of the Orca Group to Paleocene through early middle Eocene (51-53+1.6 Ma). This age limit is taken as the emplacement age of the early middle Eocene plutons that intrude and metamorphose the sequence. The lower age range of the unit is not known, but is probably Paleocene. All available data on the age of the Orca Group suggest that it is mostly, if not entirely, younger than the supposedly correlative Ghost Rocks Formation on Kodiak Island.

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Figure 1. Index map showing distribution of the Orca Group (To, Tov) and intrusive granitic rocks (Tg) in the Prince William Sound and Katalla areas. Solid dots and numerals indicate fossil localities and sample numbers. (M)=megafossils, (C)=coccoliths; (D)=diatoms and silicoflagellates; (DF)=dinoflagellates, (P)=pollen, (R)=radiolarians; all others are foraminifers. Solid triangles are K/Ar-dated samples from plutons and the numerals are apparent ages in Ma (Winkler and Plafker, 1981; and unpublished data).

Figure 2. Age ranges of fossil collections from the Orca Group (numerals in parentheses indicate number of assemblages) and K-Ar ages of mineral separates from plutons intrusive into the Orca Group. Dashed range bar indicates uncertain age range. Locations shown on Figure 1. Time scale and foraminiferal zones after Berggren, 1984).

Table 1. *Checklist of megafossils from the Orca Group

Location: U.S.G.S. locality M2063, Johnston Cove near Valdez Arm.

Age: Eocene, possibly middle Eocene.

CRABS

*Branchioplax washingtoniana* Rathbun

*Raninoides vaderensis* Rathbun

MOLLUSKS

*Acila decisa* (Conrad)

*Periploma* cf. *P. eodiscus* Vokes

*Musashia* (*Nipponomelon*) sp. cf. *M.* (*N.*) *shikamai* Moore

?Cancellarid

*Plafker and MacNeil (1966); Addicott and Plafker (1971); Ellen Moore, written commun., 10/28/85.

Table 2. *Checklist of foraminifers from the Orca Group

| Name \ Sample No. | 71AWK 130B | 71AWK 176D | 81APr 39D | 81AMH 107A | 72APr 2A2B | 80AMH 002Z | 82ADU 92B | 71AWK 51A,B | 71AWK 176A,B,D | 71AWK 22B | 81ANS 104B | 80AWK 077C | 73APr 167B | 72APr 2A2A,C | 80AMH 002A | 81ANS 107B | 81APr 37C | 84APr 6J | 84APr 6E | 71AWK 22B | 81APr 43G | 81ADU 40H | 80ANS 096A | 80ANS 102C | 80APr 6I | 80ADU 004A | 81ADU 035A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PLANKTONIC FORAMINIFERS** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Globergerina eocaena | | | | | | | | | | | | | | | | | | | C | | | ? | X | X | | | |
| G. linaperta | | | | | | | | | | | | | | | | | | X | C | | | | | X | | | |
| G. nitida | | | | | | | | | | | | | X | | | | X | | | | | | | | | | |
| Globigerina sp. (small) | | | | C | | | | | | | C | X | | | | | | | | | | | | | | | |
| Globigerina sp. (large) | | | | R | | | | | | | R | | | | | | | | X | X | | | | | | | C |
| Globigerina sp. (small & large) | | | X | | | C | R | X | C | X | | | X | | | X | X | X | | | | | | | | | |
| Globigerina sp. | | C | | | C | | | | | | | | | X | | | | | | | | | | | X | C | |
| Globigerinatheka index | | | | | | | | | | | | | | | | | | | | X | | | C | C | | | |
| G. mexicana | | | | | | | | | | | | | | | | | | | | | | | | C | ? | | |
| Globorotalia aequa? | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| Gl. aragonensis | | | | | | | | | | | | | | | | X | X | X | | ? | | | | | C | | |
| Gl. bullbrooki | | | | | | | | | | | | | | | | | | | | | | | X | X | C | | |
| Gl. chapmani? | | | | X | | | | | | | R | | | | | | | | | | | | | | | | |
| Gl. pentacamerata | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| Gl. pseudotopilensis | | | | | | | | | | | R | | X | ? | | X | | X | | | | | | X | | | |
| Gl. quetra | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| Gl. spinulosa | | | | | | | | | | | | | | | | | | | | | | | X | X | | | |
| Gl. topilensis | | | | | | | | | | | | | | | | | | | | | | | | | C | | |
| G. velascoensis? | | | | | | | | | | | | | | ? | | | ? | | | | | | | | | | |
| Globorotalia sp. (small) | | | R | X | R | | | X | | | | | | | | X | | | X | | | | | | | | |
| Hantkenina sp. | | | | | | | | | | | | | | | | | | X | | | | X | | | | X | |
| Pseudohastingerina wilcoxensis? | | | | | | | | | | | R | | | | | | | | | | | | | | | | |
| Pseudohastingerina sp. | | | | | | | | | | | | | | | | | X | | C | | | | | | X | | |
| Truncorotaloides rohri? | | | | | | | | | | | | | | | | | | | | | | X | | | | X | |
| **BENTHONIC FORAMINIFERS** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bolivina sp. | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| Discocyclina sp. | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| Eouverigerina sp. | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| Gyroidina sp. | | | | | | X | | | | | | ? | | | X | | | | | | | | | | | | |
| Hoeglundina sp. | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| Lepidocyclina sp. | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| Pseudogloborotalia sp. | R | | | | ? | | | | | | | | X | X | | | | | | | | | | | | | |
| Spiroloculina sp. | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| Textularia sp. | | | | | | X | | | | | | | | | | | | | | X | X | | | | | | |
| **MISCELLANEOUS** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Radiolarians | | X | | | X | X | | | X | | | X | X | | X | X | | | X | | | | | | | X | |
| Bryozoans | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| Fusulinids | | | | | | | | | | | R | | | | | | | | | | | | | | | | |

X = present
R = rare to few
C = common
? = uncertain identification
* Gerta Keller, written commun., 8/27/84.

Table 3. *Sample number, location, and age of foraminiferal assemblages from the Orca Group

(See Table 2 for checklist of species and Figure 1 for locations.)

| Sample No | Location | Age |
|---|---|---|
| 71AWK130B | Hawkins Island | Paleocene(?) |
| 81APR39D | Cape Martin | |
| 81AMH107A | " " | |
| 81ADU92B | Porcupine Point | |
| 71AWK176A,B,D | Hinchinbrook Island | |
| 71AWK51A,B | " " | |
| 72AWK22B | " " | |
| 81ANS104B | Whale Island | Late Paleocene to early Oligocene |
| 73APR167B | Fox Island | |
| 84APR6E | Fox Island | |
| 72APR2A2A,B,C | Cordova | |
| 80AWK77C | Neck Point | Paleocene or Eocene to early Oligocene |
| 80AMH2Z | Jeanie Point | |
| 80AMH2A | " " | |
| 81ANS107B | Fox Island | Early Eocene (P6-P7) |
| 84APR6J | " " | |
| 81APR37C | Hinchinbrook Island | |
| 81APR43G | Fox Island | Middle Eocene (P7-P12) |
| 71AWK22B | Hinchinbrook Island | |
| 84APR6I | Fox Island | Middle Eocene (P11-P12) |
| 80ANS96A | Hinchinbrook Island | |
| 80ANS102C | " " | |
| 81ADU40H | Jeanie Point | Middle to late Eocene |
| 80ADU4A | " " | |
| 81ADU35A | " " | |

*Ages and zonation after Berggren and others (1984).

Table 4. *Diatoms and silicoflagellates from the Orca Group

Sample #54AMr4B. Late early Eocene to possible early late Eocene.

DIATOMS

_Actinoptychus_ sp.

_Arachnoidiscus_ sp.

_Auliscus_ sp.

_Coscinodiscus_ sp. cf. _C. lineatus_ Ehrenberg

_Hemiaulus polymorphus_ Grunow

_Isthmia_ sp. cf. _I. nervosa_ Kutzing

_Melosira sulcata_ (Ehrenberg) Kutzing

_M. hannae_ Kanaya

_Melosira architecturalis_ Brun

_Pyxilla gracilis_ Tempere and Forti

_P. gracilis_ var. _saratoviana_ (Patocsek) Tempere and Forti

_Stephanopyxis turris_ (Greville and Arnott) Ralfs

_S._ sp. cf. _S. turris_ (Greville and Arnott) Ralfs

_Triceratium_ sp. cf. _T. nobilis_ Witt

_Xanthiopyxis_ sp. cf. _X. ovalis_ Lohman

_X. mexicana_ Kanaya

_X._ sp. cf. _X. mexicana_ Kanaya

SILICOFLAGELLATES

_Corbisema apiculata_ (Lemmerman) Hanna

_Naviculopsis foliacea_ Deflandre

*K. E. Lohman, written commun., 9/19/57; J. A. Barron, written commun., 3/14/75 and oral commun., 10/22/84.

Table 5. *Radiolarians from the Orca Group

| Age | Late early Eocene to Oligocene | Late Paleocene to late Eocene | Early Eocene to Oligocene | Eocene | Middle or late Eocene | | | | Early early Eocene |
|---|---|---|---|---|---|---|---|---|---|
| Sample no. / Species | 81ADU 36B | 81ADU 35I | 81ADU 35J | 81ANS 45C | 80AMH 177C | 81AMH 98C | 81AMH 98B | 81AMH 98A | 84APR 6K2 |
| *Amphicraspedum* sp......... | ... | ... | ... | ... | ... | ... | ... | R.. | ... |
| *Buryella clinata* Foreman.. | ... | ... | ... | ... | ... | ... | ... | ... | X.. |
| *Carpocanistrum* sp......... | ... | ... | ... | ... | ... | R.. | V.. | ... | ... |
| *Lithocyclia* sp............ | ... | ... | ... | ... | V.. | ... | V.. | ... | ... |
| *Lithocyrtis archaea* Riedel and Sanfillipo........... | ... | ... | ... | ... | ... | ... | ... | ... | X.. |
| *Periphaena delta?*......... | ... | ... | ... | A.. | ... | ... | .. | ... | ... |
| *Phormocyrtis ligulata*..... | ... | ... | ... | ... | ... | ... | R.. | R.. | ... |
| *Podocyrtis* group.......... | ... | ... | ... | ... | V.. | R.. | R.. | R.. | ... |
| *Porodiscus charlestonensis* | ... | ... | #.. | R... | R.. | F.. | #.. | F.. | ... |
| *Porodiscus circularis*..... | ... | ... | ... | .... | ... | ... | R.. | ... | ... |
| *Porodiscus* sp............. | ... | ... | ... | ... | ... | ... | R.. | R.. | ... |
| *Pterocodon*(?) *tenellus* Foreman................. | ... | ... | ... | ... | ... | ... | ... | ... | X.. |
| *Spongodiscus pulcher*...... | ... | ... | ... | .... | ... | V.. | R.. | ... | X.. |
| *Spongodiscus* sp........... | ... | ... | ... | ... | R.. | ... | ... | C.. | ... |
| *Stylodictya* sp............ | ... | ... | R.. | R.. | ... | ... | ... | ... | ... |
| *Stylosphaera coronata* coronata Ehrenberg...... | ... | ... | ... | ... | ... | ... | ... | ... | X.. |
| *Stylosphaera* sp........... | ... | R.. | R.. | F.. | R.. | F.. | F.. | F.. | ... |
| *Thyroscyrtis triacantha*... | V.. | ... | ... | ... | ... | ... | ... | ... | ... |

# = possible fragments; V = 1 specimen; R = 2-5; F = 6-15; C = 16-50; A = >50;
X = present.

*J. R. Blueford, written commun., 9/9/83;
C. D. Blome, written commun., 6/5/85 (sample 64APR6K2 only).

## Table 6. Coccoliths from the Orca Group

Sample No.: 80AWK 77C. Age: Questionable late Eocene or Oligocene.

*Coccolithus pelagicus* Wallich ?

*Dictyococcites bisectus* (Hay et al.)?

*Zygrhablithus bijugatus* Deflandre?

*David Bukry, written commun., 7/11/83.

## Table 7. *Dinoflagellates from the Orca Group

Sample No.: 80AMH2Z. Age: Eocene (probably early or middle Eocene).

*Hystrichostrogylon membraniphorum*

*Spiniferites* sp.

*Systematophora*?

*Tom Ager and Lucy Edwards, written commun., 8/26/83.

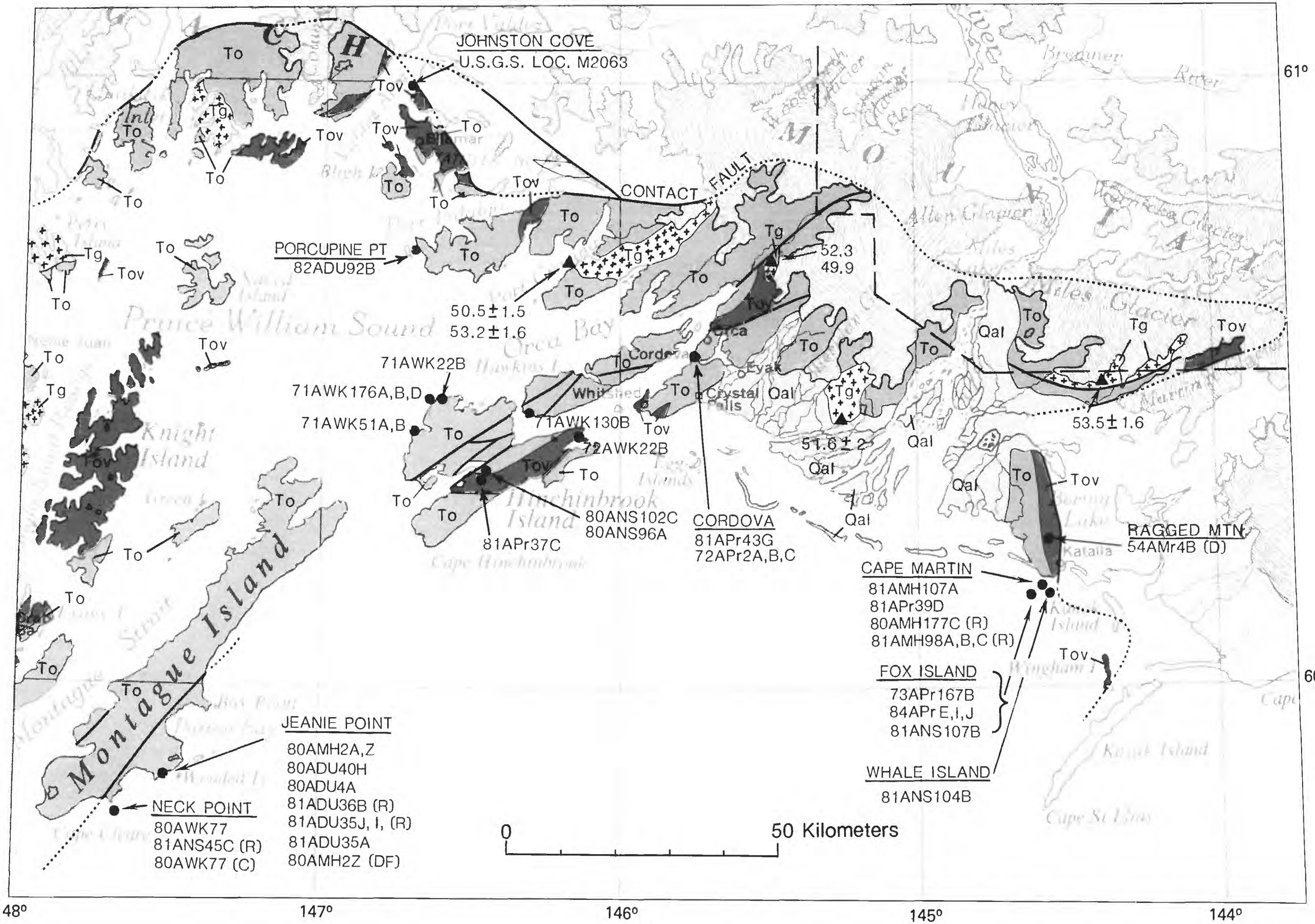


Figure 1. Index map showing distribution of the Orca Group (To, Tov) and intrusive granitic rocks (Tg) in the Prince William Sound and Katalla areas. Solid dots and numerals indicate fossil localities and sample numbers. (M)=megafossils, (C)=coccoliths; (D)=diatoms and silicoflagellates; (DF)=dinoflagellates, (P)=pollen, (R)=radiolarians; all others are foraminifers. Solid triangles are K/Ar-dated samples from plutons and the numerals are apparent ages in Ma (Winkler and Plafker, 1981; and unpublished data).

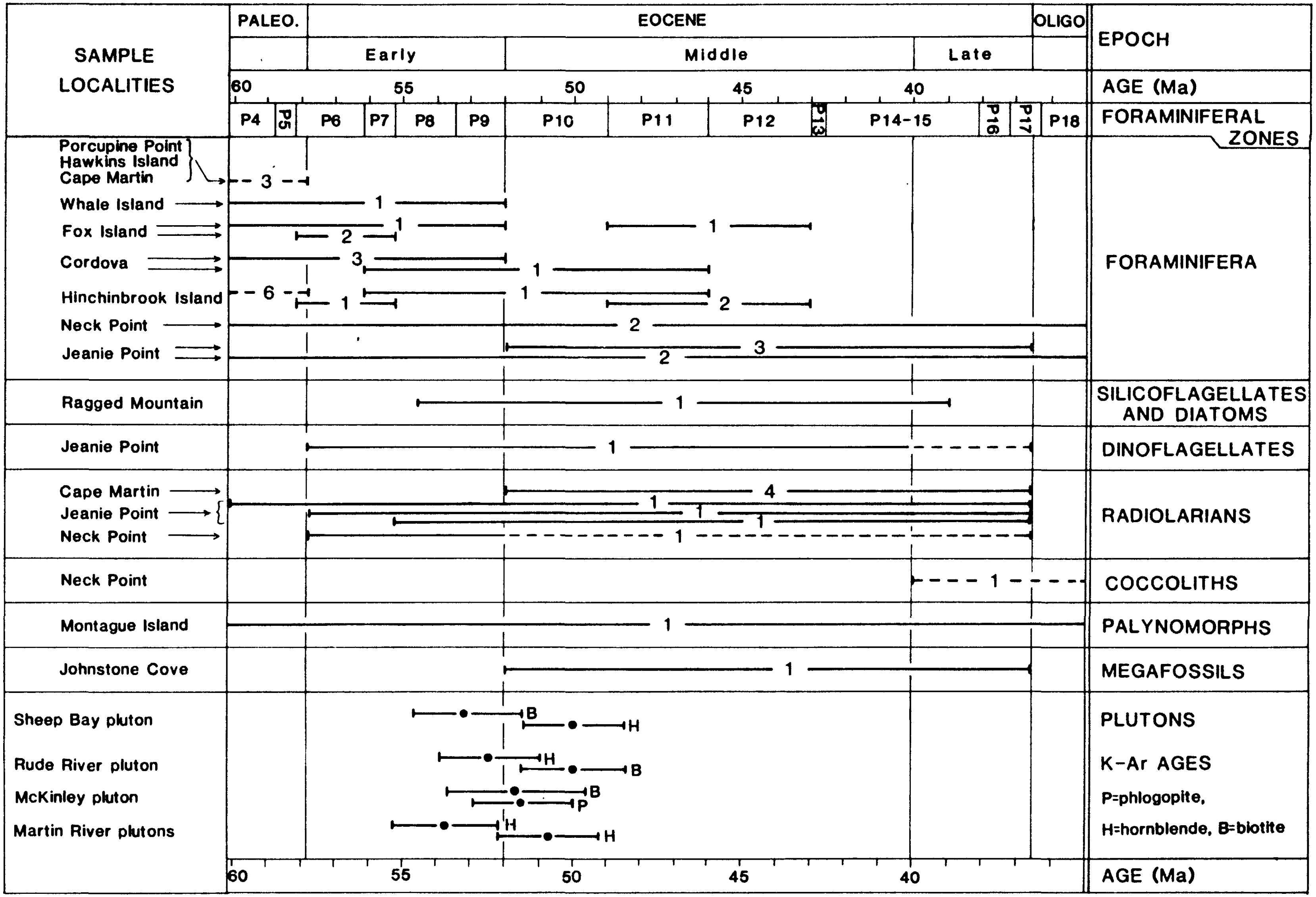


Figure 2. Age ranges of fossil collections from the Orca Group (numerals in parentheses indicate number of assemblages) and K-Ar ages of mineral separates from plutons intrusive into the Orca Group. Dashed range bar indicates uncertain age range. Locations shown on Figure 1. Time scale and foraminiferal zones after Berggren (1984).