Geological Survey of Canada
Commission Geologique du Canada

Open File 1985

EARLY MIOCENE TO QUATERNARY FORMINIFERA FROM THREE WELLSIN THE SOUTHERN QUEEN CHARLOTTE BASIN

R.T. Patterson

(Supply and Services Canada Contract
03SG.23294-7-00765/01-SG
"Part of the Program of the Federal
Panel on Energy R&D [PERD]")

Geological Survey of Canada (Calgary)
3303 - 33 Street NW
Calgary, Alberta T2L 2A7

1989

Neogene Foraminifera From the Queen Charlotte Basin

ABSTRACT

Forty-two species of benthic and planktic foraminifera were identified in 296 samples from the Shell Anglo Murrelet L-15, Harlequin D-86, and Osprey D-36 wells located in the Queen Charlotte Basin . Two distinct temporal and four distinct depositional environments were recognizable. Interpretations, however, were limited by major zones of faunal non-recovery, sparse foraminiferal fauna, and low numbers of specimens recovered from each sample.

In the upper portion of both the Harlequin D-86 and Osprey D-36 wells a well-developed and essentially modern boreal benthic foraminiferal community was identified. The upper portions of these wells were characterized by such neritic (<200 m water depth) species as Buccel*la frigida* (Cushman), 1922, *Cribroelphidium excavatum* (Terquem), 1876, *Euuvigerina juncea* (Cushman and Todd), 1941, and *Islandiella limbata* (Cushman and Hughes), 1925. Other taxa characteristic of this neritic interval, although rare, included *Buliminella elegantissima* (d'Orbigny), 1839, *Glabratella ornatissima* (Cushman), 1925, and *Pullenia salisburyi* Stewart and Stewart, 1930. Because all species found in this zone range from at least the Pliocene and are extant, biostratigraphic resolution of finer than the Pliocene-Quaternary was not possible. The upper zone of the Murrelet L-15 well virtually was devoid of fauna, but tentatively can be interpreted as Pliocene-Quaternary.

The lower faunal zone of the Osprey D-36 well was separated from the upper Pliocene-Quaternary boreal fauna zone by a 640 m hiatus in sampling that occurred between samples 35 (1036-1052 m) and 37 (1687-1697 m). The upper fauna zone of the Murrelet L-15 well was separated from the upper zone by an area of non-recovery which spanned over 1700 m. This interval was composed primarily of Upper Miocene and Pliocene non-marine sandstone and shale. The lower faunal zone identified in the Harlequin D-86 well occurred below sample 22 (1006-1021 m). Seismic data indicate that the upper and lower faunal zones identified in all three wells were separated by two regional unconformities that occurred in the Late Miocene and Pliocene.

The lower faunal zone of the Osprey D-36 well can be divided into two units. The upper unit of this interval — between 1687 and 2312 m — was characterized by an Early Miocene (Saucesian-Relizian Stage) slope assemblage. Species identified in this assemblage included the bathyal (200-1500 m water depth) dwelling Uvigerinella ornata Cushman, 1926, *Bolivina advena* Cushman, 1925, *Pseudononion costiferum* (Cushman), 1926, and the warm water, bathyal dwelling *Transversigerina transversa* Cushman, 1918. The foraminiferal fauna of the depositional unit below 2312 m in Osprey D-36 lacked *Transversigerina transversa* . In addition, this lower depositional unit included a sandstone interval that was barren of foraminifera and marked by the unusual presence of coal. This phenomenon suggests the occurrence of at least one shallower marine-transgressive/ continental-regressive cycle during Early Miocene deposition at the locality.

Neritic water depth Miocene faunas, characterized by *Cribroelphidium vulgare* (Voloshinova), 1952, were found in the lower faunal zones of both the Murrelet L-15 and Harlequin D-86 wells. The presence of these faunas suggests that the Southern Queen Charlotte Basin was more shallow toward the north in the Early-Mid Miocene. The lower foraminifera-bearing zone of the Murrelet L-15 well also included three coal seams. These seams indicate that there were alternating shallow-marine and nonmarine conditions during deposition of the basal unit of the well. The presence of *Bolivina advena* in the lower portion of the Harlequin D-86 well indicates that these sediments were deposited no later than the Middle Miocene (Luisian Stage). The lower fauna-bearing sediments of the Murrelet L-15 well also most were likely deposited during this time, as by the Late Miocene the site had become completely inundated by nonmarine sediments.

The Miocene foraminifera from the Harlequin D-86 and Murrelet L-15 wells exhibited extensive diagenesis that was recognizable from the darkened and coarse, granular recrystallized tests of the specimens. This phenomenon suggests that there may be a higher degree of thermal and geochemical maturity as one moves northward in the southern Queen Charlotte Basin.

INTRODUCTION

During the 1960's several onshore and offshore exploration wells were drilled across the Queen Charlotte Basin to determine the hydrocarbon potential of the region. After an almost 20 year hiatus in exploration activity in the Queen Charlotte Basin, there is renewed interest in the area. The purpose of this study is to analyze quantitatively the benthic and planktonic foraminiferal fauna found in three wells (Fig. 1), Murrelet L-15, Harlequin D-86, and Osprey D-36, located in the southern part of the Basin, and to provide a biostratigraphic and paleoceanographic interpretation of the resultant data. It is also the purpose of this study to illustrate fully the foraminiferal fauna with scanning electron micrographs, and to upgrade the systematics of the various taxa to provide a data base in order to facilitate future study and exploration of the basin. However, as systematic data and illustrations are beyond the scope of an open file report these are being presented separately (Patterson, in press)

GEOLOGIC HISTORY OF THE QUEEN CHARLOTTE BASIN

The Tertiary deposits of the Queen Charlotte Basin lie westward of the Coast Range Batholith to the Queen Charlotte Fault, beneath modern Hecate Strait and Queen Charlotte Sound (Fig. 1). Pre-Neogene deposits of the basin, as determined from outcrops on the Queen Charlotte Islands, are composed of over 9000 m of Mesozoic and early Tertiary Sedimentary, Metamorphic, Igneous, and Volcanic rocks. Cameron and Hamilton (1988), have determined that the oldest of the depositional units in the basin is composed of volcanic rocks of the Triassic Karmutsen Formation. To date, fully marine units have been found only in wells from the southern part of the basin. The deposits from these wells date from the Early Miocene. The Miocene deposits of the Queen Charlotte Basin range from nonmarine mudstones, sandstones, lignite, and pebble conglomerate in the north to marine sandstones, siltstones, and shales in the south, and are known as the Skonun Formation (Sutherland Brown, 1968).

Seismic mapping has shown that deposition in the southern area of the basin occurred over a varied relief volcanic terrain (Shouldice, 1971). In general, deposition which occurred to the north of the Murrelet L-15 well was nonmarine to very shallow marine, while deposition at the sites of the Harlequin D-86 and Osprey D-36 wells was mostly deeper marine. Murrelet L-15 is located at the boundary of the marine/non-marine facies; the base of the well is marine, with a few non-marine intervals, which is followed by a thick Late Miocene/Pliocene non-marine unit, and in turn is overlain by a Plio-Quaternary marine unit. Shouldice (1971) has interpreted this lithology as indicating the existence of an initial transgression occurring in the Miocene which flooded the various topographic lows and then was followed by a minor Late Miocene regression, as is seen from the non-marine units found at the Murrelet L-15 site. The foraminiferal evidence developed in the present study indicates that a second transgression occurred in the Pliocene. Two regional unconformities, spanning parts of the Late Miocene and Early Pliocene, have been recognized from seismic profiles (Shouldice, 1971).

Due to structural and lithological complexities in the region, a correlation between the Murrelet L-15, Harlequin D-86, and Osprey D-36 wells is not possible using mechanical logs or lithologies. Such an analysis is possible only through interpretions of seismic, palynological, or foraminiferal data (Shouldice, 1971).

LITHOLOGY AND DRILLING HISTORY

Shell Anglo Murrelet L-15

Shell Anglo Murrelet L-15, drilled as part of Shell Canada's west coast offshore exploratory program, was sited 32 km east of Scudder Point, Queen Charlotte Islands (Fig. 1) in 111 m of water. The well history report did not state the purpose of drilling the well, however, as with Shell's other wells in the basin, Murrelet L-15 most likely was drilled as a stratigraphic test. The well was spudded on April 11, 1969 and abandoned on May 4, 1969, at a total depth (T.D.) of 2919 m.

Conventional open-hole logs and sidewall samples were obtained prior to placing intermediate casing in the well. This casing was set to a depth of 1066 m. The lithology from the surface to 1164 m consists primarily of sandstone (90%) interspersed with a few silt, clay, mud, and shale beds. This section is situated at the top of a micropaleontological sampling hiatus. This lithology continues through the hiatus. The frequency and thickness of the silt, clay, mud, and shale beds increases below the hiatus, an interval from 2006 to 2545 m, although sandstone still comprises more than 50% of the section (Fig. 2).

Below the 2545 m level of the well, a dramatic shift in lithology occurs. From 2545 m to 2825 m, the proportion of sandstone becomes even more reduced, and three coal seams, at 2545, 2717, and 2821 m respectively, were found in the well. The base of the section from 2826 m to T.D. is composed primarily of detrital volcanic material and a few thin

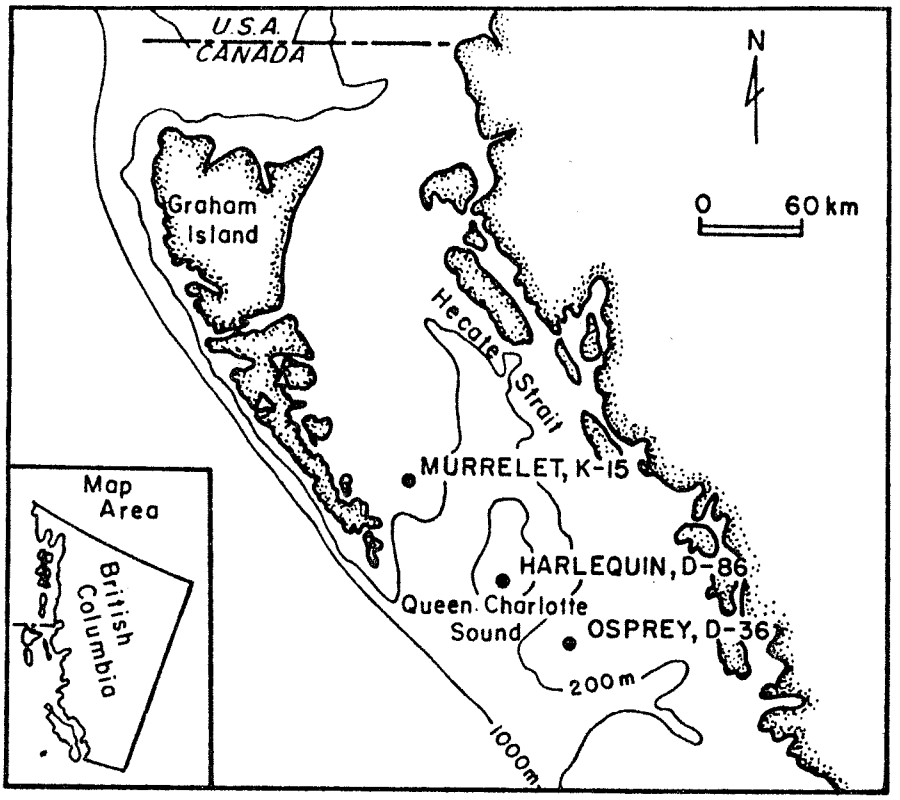

Figure 1. Location map of Queen Charlotte Basin.

shale beds (Fig. 2).

Shell Anglo Harlequin D-86

Shell Anglo Harlequin D-86, also drilled as part of Shell Canada's west coast offshore exploratory program, was drilled approximately 74 km due east of Cape St. James, Queen Charlotte Islands (Fig. 1) in 140 m of water. The purpose of the well was to perform a stratigraphic test of the basin without reference to any particular geologic structure. The well was spudded on September 22, 1968 and plugged and abandoned on October 15, 1968 at a total depth of 3241 m.

As with Murrelet L-15, conventional open-hole logs and sidewall samples were obtained prior to setting intermediate casing to a depth of 1100 m. In addition, two conventional cores were cut from 1352-1359 m and 1676-1684 m to determine the resevoir characteristics of the formation. Caliper logs showed notable caving at several intervals in the well at the following depths: 314-610 m; 701-914 m; 1253-1308 m; 1463-1527 m; 1622-1859 m; 1957-2018 m; 2067-2271 m; 2286-2384 m (minor); 2411-2954 m (minor); and 3127-3170 m.

The lithology of Harlequin D-86 generally is uniform until near the base of the well. From 384 m to 1734 m, the lithology is approximately 30% siltstone and 10% shale and the remainder is sandstone. From 1734 m to 1807 m, there was a sampling hiatus. However, the sonic and gamma logs suggest that there is little change in lithology. From 1807 to 3018 m, the lithology is similar to that found in the upper part of the core. From 3018 m to 3149 m the lithology is approximately 80% siltstone, and approximately 10% each of sandstone and shale. In addition, approximately 3 m of volcanics were observed between 3135 and 3138 m. From 3149 m to the total depth of 3241 m, the lithology changed radically consisting of igneous, volcanic and tuffaceous intervals with a few interbedded shales (Fig. 3).

Shell Anglo Osprey D-36

Shell Anglo Osprey D-36, a third well drilled as part of Shell Canada's west coast offshore exploratory program, was drilled approximately 97 km northwest of Cape Scott, Vancouver Island (Fig. 1) in 59 m of water. The purpose of the well was to conduct a stratigraphic test of the basin without reference to any particular structure. The well was spudded on September 10, 1968 and was plugged and abandoned on September 16, 1968 at a total depth of 2530 m.

Similar to Murrelet L-15 and Harlequin D-86, conventional open-hole logs and sidewall samples were obtained prior to placing intermediate casing in the well to a depth of 1056 m. A six meter conventional core was cut at 1754 m for stratigraphic control. The caliper logs indicate that there was considerable down-hole caving in Osprey D-36 at the following depths: several short intervals at 210-655 m; 731-747 m; below the last casing from 1074-1219 m; 1234-1250 m; 1387-1524 m (minor); and 1920-1966 m.

In the Osprey D-36 well, a foraminiferal sampling hiatus occurs from 1037 to 1688 m. The lithology above this hiatus consists of alternating units of mudstone (33%), sandstone (24%), shale (19%), and siltstone (18%), with mudstones more prevalent near the top of the interval, and shales more common near the base. The lithology below the sampling hiatus, from 1688 m to 1886 m, is similar to that found in the upper part of the core. However, the lithology from 1886 m to the base of the well — 2529 m — changes dramatically. This lower interval is dominated by thick volcanic intervals, interspaced with thinner sandstone and siltstone units. In the volcanic sections the gamma log values drop and the sonic velocities increase. However, the sonic values are highly irregular, and often drop toward the value of the sediments. This most likely indicates that the volcanics are not solid basalts, but rather may consist of some flows, interspersed with volcanically derived sediments — possibly pyroclastics, reworked pyroclastics, or eroded basalts (J. White, pers. comm., 1988). Of particular interest in the lower interval is the coal-bearing sandstone found between 2347 m and 2362 m. The existence of coal here indicates that this unit probably was deposited under continental rather than marine conditions (Fig. 4).

METHODS AND MATERIALS

The foraminiferal fauna from previously-picked slides obtained from three wells drilled in the Queen Charlotte basin was identified. The wells and intervals examined were Murrelet L-15, 330 m to 2914 m (60 slides); Harlequin D-86, 385 m to 3237 m (94 slides); and Osprey D-36, 296 m to 2530 m (142 slides). The stratigraphic position of these samples originally were recorded in ft, and those measurements are inscribed on the picked slides. To avoid confusion, Appendices 1-3 provide a cross reference between the metric units used herein and the original English units.

Taxa were semi-quantitatively tallied using a Wild-Heerbrugg M-8 stereoscopic dissecting microscope. A single occurrence of a species in a sample was classified as very rare, two to four occurrences were classified as rare, five to nine occurrences of a species were termed common, ten to fifteen occurrences were deemed frequent, and any species with

more than fifteen specimens in a particular sample was classified as abundant (Figs. 2-4). The biostratigraphic ranges and relative frequency of each additional species were plotted using the Checklist II program on an IBM XT personal computer. Additional figures were prepared using various drafting programs on a Macintosh SE personal computer. All taxa were illustrated using an ISI Super-III Scanning Electron Microscope with Polaroid P/N 55 positive-negative film.

RESULTS

Murrelet L-15

Faunal analysis of Murrelet L-15, the most northerly of the three wells in the Queen Charlotte Basin, was based on 60 previously-picked slides obtained from the 330 meter to 2911 meter level of the well. Only thirteen of the 60 samples yielded identifiable taxa (Fig. 2).

The fauna from Murrelet L-15 formed two identifiable clusters which were separated by a long interval composed of nonmarine sandstone and shale. A single occurrence of Pro*cerolagena distoma* (Parker and Jones), 1864, in sample 1 (330-337 m), and a rare occurrence of the long ranging Cassi*dulina teretis* Tappan, 1951, in sample 3 (374-383 m) were the only taxa found in the upper faunal zone.

Samples 4 (402-411 m) through 33 (2107-2117 m) bore no foraminifera. These samples correspond to the nonmarine interval of the well. Following the extensive faunal hiatus, taxa recovered from samples 34 (2145-2154 m) through 51 (2634-2637 m) identified a second foraminifera-bearing zone. Alternating marine and nonmarine conditions existed during this interval, as indicated by the coal seam at 2545 m. This zone was characterized by rare occurrences of the Miocene species Cribroelphidium vulgare (Voloshinova), 1952, first described from the Miocene of Sakhalin Island in the eastern U.S.S.R. (Voloshinova, 1952). All samples below this zone, sample 52 (2667-2670 m) through sample 60 (2911-2914 m) — the base of the sampled interval — were void. With the exception of the single specimen of Procerolag*ena distoma* found in the uppermost sample, the foraminiferal specimens observed in the samples from Murrelet L-15 were altered by diagenesis and were very poorly preserved. The effects of diagenesis were evident from the dark colour of many of the specimens, making them barely recognizable, and the very coarse texture of the calcite in their walls.

Harlequin D-86

Ninety-four samples ranging from 384 m to 3237 m were examined from Harlequin D-86 (Fig. 3), which was spudded south of Murrelet L-15. A total of thirty-two foraminiferal taxa were identified in seventy-five samples; nineteen samples were devoid of foraminifers. The fauna observed in Harlequin D-86 were better preserved than that found in Murrelet L-15. However, the fauna identified in sample 60 (2196-2206 m) and below were diagenically altered, and often difficult to identify due to poor preservation. Similar to the foraminifera from the Murrelet L-15 well, the diagenetically altered specimens from Harlequin D-86 exhibited darkened tests and recrystallized calcite resulting in a coarse granular wall texture. Foraminifera were most abundant in the shale, siltstone, and clay units, being almost entirely absent in the sandy units.

Several species, such as Cassidulina tere*tis* and *Epistominella pacifica* (Cushman), 1927, were fairly abundant and found throughout most of the interval. Thus, these species are of little biostratigraphic use. *Buccella inusitata* Andersen, 1952, found in many samples from sample 20 (945-960 m) to sample 83 (2911-2914) was somewhat restricted in range. However, the species originally was described from Recent sediments in the Strait of Juan de Fuca (Andersen, 1952), and therefore also is of limited biostratigraphic use. This is the first report of this species in older than Recent sediments.

Other species were found to be more restricted in range. Cribr*oelphidium excavatum* (Terquem), 1876, common in modern shelf depth waters in the Northeastern Pacific (Bergen and O'Neil, 1979; Cockbain, 1963) was very rare in samples 2 (404-413 m) through 4 (457-472 m). Islandiell*a limbata* (Cushman and Hughes), 1925, was very rare to frequent in samples 4 (457-472 m) through 9 (610-6254 m). Euuvigerin*a juncea,* first described from Pliocene sediments (Cushman and Todd,1941), was very rare to abundant in most samples beginning with sample 7 (549-564 m) through sample 31 (1284-1293 m). Both Euuvigerin*a juncea* and *Islandiella limbata* are common in modern shallow waters along the Pacific west coast (Bergen and O'Neil, 1979; Cockbain, 1963; Douglas et al., 1979; Douglas, 1981). Other taxa even more rare, were identified in the upper interval of Harlequin D-86. These species included *Glabratella ornatissima* (Cushman) 1925, *Angulogerina fluens* (Todd), 1948, *Buliminella elegantissima* (d'Orbigny), 1939, and *Pullenia salisburyi* Stewart and Stewart, 1930. All of these species presently are common in neritic depth waters along the Pacific coast of North America (Bergen and O'Neil, 1979; Douglas et al., 1979; Erskian and Lipps, 1987; Todd and Low, 1967).

Several Miocene species also exhibited re-

stricted ranges in Harlequin D-86. *Bolivina advena* Cushman, 1925, typical of Early (Saucesian Stage) to Middle Miocene (Luisian Stage) sediments from California (Kleinpell, 1938; Kleinpell, et al., 1980), was very rare to frequent in the short interval from sample 22 (1006-1021 m) to sample 28 (1189-1204 m). Cribroelph*idium vulgare* was very rare to abundant in many samples ranging from sample 39 (1541-1553 m) to sample 92 (3185-3188 m). A portion of the range of Euuvigerina *juncea* overlaps the entire range of *Bolivina advena.* Although down-hole contamination is an important concern when interpreting the fauna from this well, the presence of casing down to 1100 m indicates that the overlap of these species is real and that Euuvi*gerina juncea* has a much greater biostratigraphic range than previously known.

In Harlequin D-86, *Nonionella miocenica* also had a restricted range with a single very rare occurrence in sample 20 (945-960 m), and then rare to abundant occurrences in samples 69 (2484-2487 m) to 93 (3216-3219 m). Nonionella mioc*enica* also was restricted to Miocene samples from Osprey D-36. This species was first described in samples from the Miocene Monterey Formation of Southern California, (Cushman, 1925). However, because *Nonionella miocenica* also has been identified in sediments from the Pliocene and Pleistocene of the Humboldt Basin of Northern California (Haller,1980), its use as a biostratigraphic marker is therefore questionable. Other characteristic Miocene fauna such as *Pseudononion costiferum* (Cushman), 1926, *Siphogenerina transversa* Cushman, 1918, and *Uvigerinella ornata* Cushman, 1926, common in many samples from the Osprey D-36 well, were absent or very rare in Harlequin D-86. The increase in abundance toward the base of the well of such taxa as *Nonionella miocenica, Buccella inusitata* and *Cribroelphidium vulgare* indicates that these species are probably in situ and have not been reworked down-hole. The volcanic unit at the base of the well, below 3149 m, is not homogenous, but instead consists of beds of volcanics, and volcanic debris, which have been interbedded with shales and other sediments. The few foraminifera found in this unit may very well be in situ as well.

Osprey D-36

One hundred and forty-two samples, ranging in depth from 298 m to 2530 m, were examined from Osprey D-36, the most southerly of the wells analyzed in this study (Fig. 4). One hundred and fourteen samples yielded thirty-five species of foraminifera, and twenty-eight samples were devoid of any fauna. Specimens in all samples, although often broken, were very well preserved and exhibited no effects of the diagenesis that characterized the faunas recovered from Murrelet L-15 and Harlequin D-86. The foraminiferal fauna found in Osprey D-36 was similar to that observed in the other two wells, however the various taxa identified in this well tended to be more abundant. Similar to what was observed in the Harlequin D-86 well, foraminifera were almost entirely absent from the sandy units. Extensive volcanic units also were observed in the lower intervals of this well. However, as these units are primarily pyroclastic sediments rather than solid basalts, it is probable that most foraminifera identified in these units are in situ and not reworked from above.

As was observed in Harlequin D-86, Cassidulina *teretis* and *Epistominella pacifica* ranged throughout the entire sampled interval. Other identifiable taxa, however, formed two distinct faunal associations associated with the upper and lower parts of the well. Unfortunately, a large sampling hiatus of 632 m, probably caused by the extensive cave-ins in this interval during drilling, separated the two zones. The sampling hiatus occurred between samples 35 (1036-1052 m) and 37 (1687-1697 m). Sample 36 (2), obtained from an unknown area within this hiatus, contained elements of both a modern boreal fauna (upper part of the well) and an Early Miocene fauna (sample 36 and below), indicating probable contamination from above.

The upper zone of Osprey D-36 included fauna similar to that found in Recent shallow shelf waters of the Northeastern Pacific Ocean (Bergen and O'Neil, 1979; Cockbain, 1963). This zone extends from the top of the sampled section to sample 35 (1036-1052 m), and was characterized by various boreal species such as Buccella frigida (Cushman), 1922. *Cribroelphidium excavatum* and *Euuvigerina juncea*, which were very rare to abundant in most samples from the upper interval, also characterized the zone. Very rare occurrences of the shallow water indicator species *Glabratella ornatissima* and *Melonis zandami* Van Voorthuysen, 1950, also were found in the upper unit.

The lower zone of the well extended from sample 37 (1687-1697 m) to the base of the section. This zone contained characteristic Early to Middle Miocene foraminifers, in addition to the two long ranging taxa identified above. The species that best delineated this zone were Boliv*ina advena, Pseudononion costiferum* and *Uvigerinella ornata. Bolivina advena* was abundant in many samples from the top of the lower zone beginning at sample 37 (1687-1697 m) to near the base of the sampled interval. Pseud*ononion costiferum* also was very abundant in the upper samples of this interval. Kleinpell et al.

(1980) report that these two species range from the Early Miocene Saucesian Stage to the Middle Miocene Luisian Stage.

A large increase in the number of foraminifera was observed at 2106 m in Osprey D-36. This increase most likely is due to down-hole contamination as log runs two and three met at this level. Down-hole contamination typically occurs immediately following a logging operation, as after drilling mud circulation renews, there is a tendency for any material which caved into the hole during the operation to be deposited on the shale shaker (J. White, pers. comm., 1988).

Uvigerinella ornata, which was very rare to abundant in the lower zone of Osprey D-36, has been identified by Kleinpell et al. (1980) in samples from the Saucesian Stage to Luisian Stage. Another important indicator species found in the lower interval of Osprey D-36, *Siphogenerina transversa* Cushman, 1918, was somewhat less common. Kleinpell et al. (1980) report that the range of this species is even more restricted than that of the other indicator species identified above, being found only in the Saucesian and the overlying Late Early Miocene Relizian Stage. *Nonionella miocenica* and *Cribroelphidium vulgare*, which were notably common in the lower part of the Harlequin D-86 well, were present in only a few samples from the lower zone of Osprey D-36.

In both the upper Plio-Pleistocene boreal fauna-bearing interval and the lower Early Miocene fauna-bearing interval of Osprey D-36, there were rare occurrences of the neritic dwelling species *Buliminella elegantissima* and *Praeglobobulimina pyrula* (d'Orbigny, 1846). Generally, the presence of these species in both the upper and lower intervals of the well would indicate down-hole contamination. However, the presence of the casing down to 1056 m in the well negates the possibility of such contamination, and suggests that these species may have ranged over the entire depositional interval.

DISCUSSION

In general, because the total number of identifiable taxa was quite small — only forty-two species — it was difficult to determine precise bathymetric ranges and ages of the foraminiferal fauna obtained from the three wells. For example, only two species were found in samples from the upper fauna-bearing zone of the Murrelet L-15 well. In addition, the low numbers of specimens obtainable from each sample, coupled with major zones of, primarily lithology related, non-recovery, increased the difficulty of arriving at a precise paleoenvironmental interpretation.

Pliocene-Quaternary

The upper faunal zones of Osprey D-36 (sample 1 [298 m] through sample 35 [1036-1052 m]), Harlequin D-86 (sample 1 [385 m] through sample 21 [975-991 m]), and Murrelet L-15 (sample 1 [329-336 m] through sample 3 [374-383 m]) consisted entirely of extant species common in the coastal waters along the northern part of the west coast of North America. Many of those species also existed in the Pliocene. However, because no definitive Pliocene or Quaternary taxa were present in all of these intervals, they must be classified as Plio-Quaternary (Fig. 5).

Based on studies from California to the Gulf of Alaska of fauna similar to that identified in the upper fauna-bearing zone of the Osprey D-36 well, the water depth of that zone most likely was somewhere between middle neritic (50-100 m) and outer neritic (100-200 m) (Bergen and O'Neil, 1979; Cockbain, 1963; Douglas et al. 1979; Douglas, 1981; and others). Bergen and O'Neil (1979) reported that species such as Cribroelphidium excavatum, Glabratella ornatissima, *Buliminella elegantissima*, and *Buccella frigida* were most common in waters less than 100 m, whereas species such as Epistominella *pacifica* and *Euuvigerina juncea* were most common at the shallower limit of the outer neritic zone, a water depth of approximately 100 m. A study of Recent foraminifera from the California borderland found several of these boreal species in slightly deeper habitats, which probably was due to the warmer water temperature of this area (Douglas, 1981). For example, Douglas (1981) found that Euuvigerina *juncea* was characteristic of the upper slope (in water depths of 85-450 m), while Buccella*frigida* was most common on offshore ridges and deep banks in depths of 100-400 m. Thus, assuming that the sediments from the upper zone of the Osprey D-36 well are Plio-Quaternary, cool water temperatures, with depths of approximately 100-200 m, probably prevailed throughout this interval of depostion in the Queen Charlotte Basin (Figs. 4, 5).

The fauna identified from the the upper zone of the Harlequin D-86 well (samples 1 to 21) is similar to that found in the upper interval of Osprey D-36. The boreal fauna found in this zone differs from that identified in Osprey D-36 only in the decreased total number of specimens recovered, which is characteristic of all samples from Harlequin D-86. The specimens in this upper interval were well preserved which indicated very little diagenetic alteration. Because the fauna from the upper (Plio-Quaternary) zone of Har-

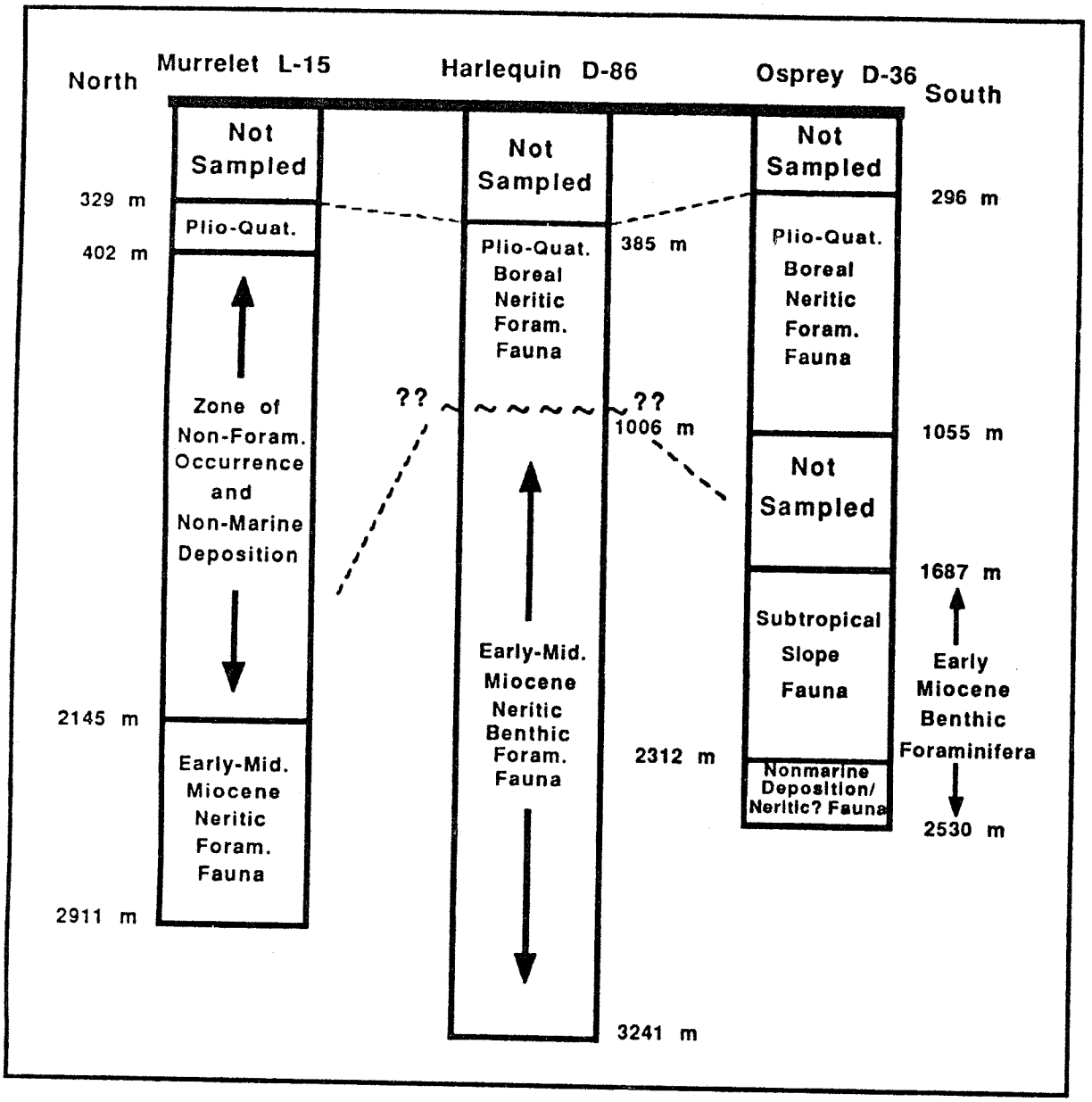

Figure 5. Foraminiferal faunal distribution in the Osprey D-36, Harlequin D-86, and Murrelet L-15 wells from the Queen Charlotte Basin off the west coast of British Columbia.

lequin D-86 were similar to that recovered from the upper (Plio-Quaternary) zone of Osprey D-36, water depth during deposition of the Harlequin D-86 upper interval (Figs. 3, 5) most likely was neritic (100-200 m).

Interpreting the fauna from the upper zone of Murrelet L-15 (samples 1 through 3) was nearly impossible as only three specimens, consisting of two species, Procerolagena distoma and Cassidulina *teretis*, were recovered. These species are found in neritic and bathyal environments (Tappan, 1951; Mackensen and Hald, 1988), and range from the Miocene to Recent. Thus, based on the varied habitats and range of these species, it is difficult to determine the depositional environment of the upper unit of Murrelet L-15. However, because the specimens recovered from this zone are better preserved than the fauna found in the lower faunal interval of the core, they most likely are Late Plio-Quaternary in age. The fact that these sediments were deposited above the Late Miocene-Pliocene nonmarine zone of the Murrelet L-15 well (Shouldice, 1971) also lends weight to this conclusion (Figs. 2, 5).

Miocene

Definite Miocene foraminifers were found in samples from all three wells. In Osprey D-36, the foraminifera specimens recovered from sample 37 (1687-1697 m) to the base of the section were well-developed and included several Miocene species. The Miocene species identified from this interval were Bolivina *advena, Pseudononion costiferum, Cribroelphidium vulgare, Lenticulina nikobarensis, Transversigerina transversa* and *Uvigerinella ornata.* Unfortunately, a major sampling unconformity of more than 600 m occurs between samples 35 and 37 (Figs. 4, 5) of the Osprey D-36 well.

Bolivina advena, Uvigerinella ornata, Pseudononion costiferum, and *Transversigerina transversa* all first appeared in the Saucesian Stage of the Early Miocene (Kleipell, 1938; Kleinpell et al. 1980). *Uvigerinella ornata* and *Pseudononion costiferum* had disappeared by the Middle Miocene Luisian. *Bolivina advena* has been found into the Late Miocene Mohnian Stage of California, while *Transversigerina transversa* had disappeared by the end of the Relizian Stage of the Late Early Miocene. Assuming that the ranges of *Bolivina advena* and *Transversigerina transversa* off British Columbia are similar to their stratigraphic distribution in California, the sediments of Osprey D-36 that contained these species could not have been deposited later than the early Miocene.

The Miocene interval of Osprey D-36 can be separated into two distinct units. The presence of *Transversigerina transversa* in the upper portion of the Miocene section — above 2312 m — suggests that warmer water temperatures and upper-middle bathyal water depths prevailed during deposition of this interval. Uvige*rinella ornata*, abundant in this upper unit as well, also indicates the existence of upper-middle bathyal water depths ranging from approximately 200-1500 m (Kleinpell, 1938; Kleinpell et al. 1980).

The lower unit — below 2314 m — of the Miocene interval of the Osprey D-36 well is characterized by alternating regions of foraminifera-bearing zones and thick sandstone sections devoid of any fauna (Figs. 4, 5). The presence of coal at 2347-2362 m, within a thick sandstone unit found at 2312-2379 m, suggests that there may have been at least one episode of continental deposition during the early history of the well. In addition, a lower, sandstone unit (2403-2464 m) also may represent the presence of another period of continental deposition. In the foraminifera-bearing zones, the upper-middle bathyal indicator species Transversigerina transversa is absent, which suggests that the lower section may have been deposited in waters more shallow than that associated with deposition of the upper portion of the Miocene interval. However, the presence of deeper dwelling *Uvigerinella ornata* in these samples may indicate that the absence of *Transversigerina transversa* is related to other factors beside depth. Thus, the samples from beneath 2312 m at Osprey D-36 most likely record alternating marine transgressive and continental regressive deposition events.

The Miocene fauna recovered from the Harlequin D-86 well — sample 22 (1005-1021 m) to the base of the section — was similar to that found, above the 2312 meter level, in Osprey D-36. However, both Transversi*gerina transversa* and *Uvigerinella ornata* were entirely absent in Harlequin D-86. One possible explanation for the absence of *Transversigerina transversa* is that the Miocene section of Harlequin D-86 was deposited after the extinction of this species and thus, is wholly Luisian. This hypothesis, however, does not explain the absence of *Uvigerinella ornata*, which also is found in the Luisian. Because both *Transversigerina transversa* and *Uvigerinella ornata* are moderately deep water dwelling species (Kleinpell, 1938; Kleinpell et al., 1980), a more probable explanation for their absence is that the depositional environment of the Harlequin D-86 Miocene section possibly was of neritic depth <200 m, and thus shallower than the higher Miocene section of Osprey D-36. Such a conclusion accounts for the predominance of Cribr*oelphidium vulgare* in this section because, although species of *Elphidium* de Montfort,

1808, and related genera, are found at many depths, they are most common in shallow inner shelf environments (Haynes, 1981). As with Osprey D-36, water temperatures associated with the Miocene interval of Harlequin D-86 most likely were warm, and the difference in identifiable fauna found in the two wells can be attributed solely to a shift in water depth, assuming that the two sections were deposited at approximately the same time (Figs. 3, 5). An interesting feature of the Harlequin D-86 well is that the Miocene fauna was located immediately below the Plio-Quaternary foraminifera. Late Miocene to Pliocene regional unconformities in the Queen Charlotte Basin, as postulated by Shouldice (1971) based on seismic evidence, most likely caused this juxaposition.

In Murrelet L-15, Miocene fauna was obtained from samples 34 (2196-2206 m) through 52 (8640-8650 ft), an area below the non-marine depostional zone of the well (Shouldice, 1971). Interpretation of the Miocene interval was difficult as the recovered fauna consisted of only four species: Cassidulina ter*etis, Buccella inusitata, Elphidiella nitida,* and *Cribroelphidium vulgare* . Of the four species, *Cribroelphidium vulgare* was the most abundant, and the only taxa that was restricted to the Miocene. The dominance of *Cribroelphidium vulgare* indicates a neritic depositional environment for the lower unit of Murrelet L-15, similar to that determined for the Miocene interval of Harlequin D-86 (Figs. 2, 5). Moreover, the Early Miocene foraminiferal fauna found in the lower intervals of both the Murrelet L-15 and Harlequin D-86 [below sample 60 (7205-7237 ft)] wells had been recrystallized to a coarse granular texture, and generally were light to dark brown in colour. This diagenetic alteration suggests that as one moves north in the Basin there is greater geochemical and thermal maturity of the sediments, which indicates a higher probability of hydrocarbons (Hunt, 1979).

A paleoenvironmental interpretation of the various wells that have been drilled in the Queen Charlotte Basin was postulated by Yorath and Hyndman (1983) based on regional geologic, geophysical, and heat flow data. Partially in concordance with the conclusions reached in the present study, Yorath and Hyndman determined that the Early Miocene portion of the Osprey D-36 well was deposited in bathyal depths (600-1750 m), and that the Murrelet L-15 well was deposited under shallow marine conditions. Yorath and Hyndman (1983), however, posited that the Early Miocene portion of the Harlequin D-86 well and the Early Miocene section beneath 2312 m at Osprey D-36 was deposited at bathyal depths, similar to the stratigraphically higher Miocene deposits at Osprey D-36 well. As discussed above, however, the close similarity of the shallow water-dwelling foraminiferal fauna found in the Early Miocene portions of the Harlequin D-86 and Murrelet L-15 wells, and their dissimilarity from the Early Miocene fauna identified from the Osprey D-36 well indicates that the depositional environment of Harlequin D-86 during this time was neritic. In addition, the presence of coal in the non-foraminiferal-bearing sandstones, and the absence of Transversigerina tr*ansversa* from the adjacent foraminiferal bearing intervals in the Miocene section below 2312 m in Osprey D-36, suggests that the depositional environment of at least part of this interval may also have been continental, and/ or shallower marine.

ACKNOWLEDGMENTS

I wish to thank James M. White at the Geological Survey of Canada Institute of Sedimentary and Petroleum Geology, Calgary, Alberta, for coordinating this project; B.E.B. Cameron, the Geological Survey of Canada, Pacific Geoscience Centre, Sidney, British Columbia for providing the samples; and H. T. Loeblich and A.R. Loeblich, Jr. at the University of California, Los Angeles, for providing scanning electron microscope facilities and aiding in the identification of some foraminiferal taxa. I also would like to thank B.E.B. Cameron, R. Higgs, G.B. Patterson, and J.M. White for critically reviewing various versions of the manuscript.

REFERENCES

ANDERSEN, H.V., 1952, *Buccella,* a new genus of the rotalid foraminifera. Washington Academy of Sciences, Journal, v. 42, p. 143-151.

BERGEN, F.W. and O'NEIL, P., 1979, Distribution of Holocene foraminifera in the Gulf of Alsaka: Journal of Paleontology, v. 53, p. 1267-1292.

CAMERON, B.E.B., and HAMILTON, T.S., 1988, Contributions to the stratigraphy and tectonics of the Queen Charlotte Basin, British Columbia: Current Research, Part E, Geological Survey of Canada, Paper 88-1E, p. 221-227.

COCKBAIN, A.E., 1963, Distribution of foraminifera in Juan de Fuca and Georgia Straits, British Columbia, Canada: Contributions From the Cushman Foundation For Foraminiferal Research, v. 14, p. 37-57.

DOUGLAS, R.G., 1981. Paleoecology of continental margin basins: a modern case history from the borderland of southern California, p. 121-156. in R.G. Douglas, I.P. Colburn, and

D.S. Gorsline (eds.), Depositional Systems of Active Continental Margin Basins: Short Course Notes, Society of Economic Paleontologists and Mineralogists, Pacific Section

DOUGLAS, R.G., COTTON, M. L. and WALL, L. 1979. Distributional and variability analysis of benthic foraminifera in the southern California Bight: Bureau of Land Management, Department of the Interior Contract AA550-CT6-40, 219 p.

ERSKIAN, M.G., and LIPPS, J.H., 1987, Population dynamics of the foraminifera Glabratella ornatissima (Cushman) in northern California: Journal of Foraminiferal Research, v. 17, p. 240-256.

HAYNES, J.R., 1981, Foraminifera: John Wiley & Sons, New York, 433 p.

HUNT, J.M., 1979, Petroleum Geochemistry and Geology: W.H. Freeman and Company, San Francisco, 617 p.

KLEINPELL, R.M., 1938. Miocene stratigraphy of California: American Association of Petroleum Geologists, Tulsa, U.S.A., 450 p.

KLEINPELL, R.M., HORNADAY, G., WARREN, A.D., and TIPTON, A., 1980, The Miocene stratigraphy of California revisited: in American Association of Petroleum Geologists, Studies in Geology No. 11, p. 182.

PATTERSON, R.T. (in press) Neogene foraminiferal biostratigraphy of the southern Queen Charlotte Basin: Geological Survey of Canada, Contributions to Paleontology.

SHELL CANADA LIMITED, 1968, Well history report Shell Anglo Osprey D-36. Calgary.

SHELL CANADA LIMITED, 1969, Well history report Shell Anglo Harlequin D-86. Calgary.

SHELL CANADA LIMITED, 1969, Well history report Shell Anglo Murrelet L-15. Calgary.

SHOULDICE, D.H., 1971, Geology of the western Canadian continental shelf: Bulletin of Canadian Petroleum Geology, v. 19, p. 405-436.

TAPPAN, H., 1951, Northern Alaska index foraminifera: Contributions From the Cushman foundation For Foraminiferal Research, v. 2, p. 1-8.

TODD, R., and LOW, D., 1967, Recent foraminifera from the Gulf of Alaska and Southeastern Alaska: U.S. Geological Survey Professional Paper 573-A, 46 p.

YORATH, C.J., and HYNDMAN, R.D., 1983, Subsidence and thermal history of Queen Charlotte Basin: Canadian Journal of Earth Science, v. 20, p. 135-159.

Appendix 1. - Shell Anglo Murrelet K-15 sample intervals.

Feet	Metres	Feet	Metres
1. 1080-1105	329-337	31. 6576-6665	2004-2032
2. 1138-1164	347-355	32. 6791-6881	2070-2097
3. 1228-1258	374-383	33. 6913-6944	2107-2117
4. 1318-1349	402-411	34. 7037-7067	2145-2154
5. 1440-1472	439-449	35. 7126-5156	3172-2181
6. 1533	467	36. 7220-7250	2201-2210
7. 1623-1651	495-503	37. 7311-7341	2228-2238
8. 1730-1760	527-537	38. 7407	2349
9. 1820-1851	555-564	39. 7556-7580	2303-2310
10. 1913-1943	583-592	40. 7590-7600	2313-2317
11. 2033-2063	619-629	41. 7640-7650	2329-2332
12. 2129-2159	649-658	42. 7740-7750	2359-2362
13. 2224-2225	678-687	43. 7840-7850	2390-2393
14. 2344-2376	715-724	44. 7940-7950	2420-2423
15. 2435-2465	742-751	45. 8050-8060	2454-2457
16. 2528-2558	771-780	46. 8160-8170	2487-2490
17. 2620-2652	799-808	47. 8240-8250	2512-2515
18. 2716-2748	828-838	48. 8340-8350	2542-2545
19. 2810-2841	857-866	49. 8450-8460	2576-2579
20. 2935-2965	895-904	50. 8550-8560	2606-2609
21. 3024-3054	922-931	51. 8640-8650	2634-2637
22. 3115-3145	950-959	52. 8750-8760	2667-2670
23. 3204-3235	977-986	53. 8850-8860	2698-2701
24. 3327-3358	1014-1024	54. 8950-8960	2728-2731
25. 3420-3451	1042-1052	55. 9050-9060	2758-2762
26. 3514-3545	1071-1081	56. 9150-9160	2789-2792
27. 3617-3663	1103-1117	57. 9250-9260	2819-2823
28. 3724-3754	1135-1144	58. 9350-9360	2850-2853
29. 3815-3845	1163-1172	59. 9450-9460	2880-2883
30. 5450-5500	1661-1676	60. 9550-9560	2911-2914

Appendix 2. - Shell Anglo Harlequin D-86 sample intervals.

Feet	Metres	Feet	Metres
1. 1263	385	48. 6040-6100	1841-1859
2. 1324-1355	404-413	49. 6120-6180	1865-1884
3. 1415-1450	431-442	50. 6180-6280	1884-1902
4. 1500-1550	457-472	51. 6317-6348	1925-1935
5. 1600-1650	488-503	52. 6408-6438	1953-1962
6. 1700-1750	518-533	53. 6500-6554	1981-1998
7. 1800-1850	549-564	54. 6621-6684	2018-2037
8. 1900-1950	579-594	55. 6715-6745	2047-2056
9. 2000-2050	610-625	56. 6804-6833	2074-2083
10. 2100-2150	640-655	57. 6926-6958	2111-2121
11. 2200-2250	671-686	58. 7019-7051	2139-2149
12. 2300-2350	701-716	59. 7113-7144	2168-2178
13. 2400-2450	732-747	60. 7205-7237	2196-2206
14. 2500-2550	762-777	61. 7303-7335	2226-2236
15. 2600-2650	793-808	62. 7402-7436	2256-2266
16. 2700-2750	823-838	63. 7514-7534	2290-2296
17. 2800-2850	853-869	64. 7620-7640	2323-2329
18. 2900-2950	884-899	65. 7740-7750	2359-2362
19. 3000-3050	914-930	66. 7820-7871	2384-2399
20. 3100-3150	945-960	67. 7940-7960	2420-2426
21. 3200-3250	975-991	68. 8040-8050	2451-2454
22. 3300-3350	1006-1021	69. 8150-8160	2484-2487
23. 3400-3450	1036-1052	70. 8250-8260	2515-2518
24. 3500-3550	1067-1082	71. 8350-8360	2545-2548
25. 3600-3650	1097-1113	72. 8450-8460	2576-2579
26. 3775	1151	73. 8550-8560	2606-2609
27. 3800-3850	1158-1174	74. 8640-8660	2634-2640
28. 3900-3950	1189-1204	75. 8730-8760	2661-2670
29. 4000-4050	1219-1234	76. 8820-8870	2688-2704
30. 4122-4152	1256-1266	77. 8940-8950	2725-2728
31. 4213-4243	1284-1293	78. 9040-9050	2755-2758
32. 4305-4346	1312-1325	79. 9150-9160	2789-2792
33. 4435-4490	1352-1369	80. 9250-9260	2819-2823
34. 4523-4554	1379-1388	81. 9350-9360	2850-2853
35. 4611-4641	1405-1415	82. 9450-9460	2880-2883
36. 4703-4733	1434-1443	83. 9550-9560	2911-2914
37. 4835-4866	1474-1483	84. 9650-9660	2941-2944
38. 4930-4963	1503-1513	85. 9750-9760	2972-2975
39. 5055-5094	1541-1553	86. 9850-9860	3002-3005
40. 5117-5150	1560-1570	87. 9950-9960	3033-3036
41. 5207-5245	1587-1599	88. 10050-10060	3063-3066
42. 5331-5363	1625-1939	89. 10150-10160	3094-3097
43. 5427-5457	1654-1663	90. 10250-10260	3124-3127
44. 5495-5563	1675-1696	91. 10350-10360	3155-3158
45. 5626-5658	1715-1725	92. 10450-10460	3185-3188
46. 5800-5820	1768-1774	93. 10550-10560	3216-3219
47. 5940-6000	1811-1829	94. 10610-10620	3234-3237

Appendix 3. - Shell Anglo Osprey D-36 sample intervals.

Feet	Metres	Feet	Metres
1. 970	29	51. 6310-6320	1923-1926
2. 1000-1030	305-314	52. 6330-6340	1929-1932
3. 1060-1090	323-332	53. 6350-6360	1936-1939
4. 1120-1160	341-354	54. 6370-6380	1942-1945
5. 1190-1220	363-372	55. 6390-6400	1948-1951
6. 1250-1280	381-390	56. 6410-6420	1954-1957
7. 1310-1340	399-408	57. 6430-6461	1960-1969
8. 1370-1400	418-427	58. 6492-6521	1979-1988
9. 1430-1460	436-445	59. 6551-6582	1997-2006
10. 1489-1526	454-465	60. 6613-6620	2016-2018
11. 1555-1584	474-483	61. 6630-6640	2021-2024
12. 1616-1646	493-502	62. 6650-6660	2027-2030
13. 1676-1710	511-521	63. 6670-6680	2033-2036
14. 1740-1772	530-540	64. 6690-6700	2039-2042
15. 1799-1830	548-558	65. 6710-6720	2045-2048
16. 1860-1891	567-576	66. 6730-6740	2051-2054
17. 1900-1930	579-588	67. 6750-6760	2057-2061
18. 1960-1990	597-607	68. 6770-6780	2064-2067
19. 2020-2060	616-628	69. 6790-6800	2070-2073
20. 2090-2120	637-646	70. 6810-6820	2076-2078
21. 2150-2180	655-665	71. 6830-6840	2082-2085
22. 2210-2240	674-683	72. 6850-6860	2088-2091
23. 2280-2310	695-704	73. 6870-6880	2094-2097
24. 2340-2370	713-722	74. 6890-6900	2100-2103
25. 2400-2450	732-747	75. 6906-6910	2105-2106
26. 2500-2550	762-777	76. 6920-6930	2109-2112
27. 2600-2650	793-808	77. 6940-6950	2115-2118
28. 2700-2750	823-838	78. 6960-6970	2121-2125
29. 2800-2850	853-869	79. 6980-6990	2128-2131
30. 2900-2950	884-899	80. 7000-7010	2134-2137
31. 3000-3050	914-930	81. 7020-7030	2140-2143
32. 3100-3150	945-960	82. 7040-7050	2146-2149
33. 3200-3250	975-991	83. 7060-7070	2152-2155
34. 3300-3350	1006-1021	84. 7080-7090	2158-2161
35. 3400-3450	1036-1052	85. 7100-7110	2164-2167
36. 3450-5535	1052-1687	86. 7120-7130	2170-2173
37. 5535-5567	1687-1697	87. 7140-7150	2176-2179
38. 5598-5629	1706-1716	88. 7160-7170	2182-2185
39. 5661-5691	1725-1735	89. 7180-7190	2189-2192
40. 5723-5762	1744-1756	90. 7200-7210	2195-2198
41. 5776-5806	1761-1770	91. 7220-7230	2201-2204
42. 5839-5869	1780-1789	92. 7240-7250	2207-2210
43. 5994-6026	1827-1837	93. 7260-7280	2213-2219
44. 6058-6090	1846-1856	94. 7300-7320	2225-2231
45. 6183-6200	1885-1890	95. 7340-7350	2237-2240
46. 6210-6220	1893-1896	96. 7360-7370	2243-2246
47. 6230-6240	1899-1902	97. 7380-7390	2249-2253
48. 6250-6260	1905-1908	98. 7400-7410	2256-2259
49. 6270-6279	1911-1914	99. 7420-7430	2262-2265
50. 6290-6300	1917-1920	100. 7440-7450	2268-2271

Appendix 3. - Shell Anglo Osprey D-36 sample intervals continued.

Feet	Metres	Feet	Metres
101. 7460-7470	2274-2277	122. 7880-7890	2402-2405
102. 7480-7490	2280-2283	123. 7900-7910	2408-2411
103. 7500-7510	2286-2289	124. 7920-7930	2414-2417
104. 7520-7530	2292-2295	125. 7940-7950	2420-2423
105. 7540-7550	2298-2301	126. 7960-7970	2426-2429
106. 7560-7570	2304-2307	127. 7980-7990	2432-2435
107. 7580-7590	2310-2313	128. 8000-8010	2438-2442
108. 7600-7610	2317-2320	129. 8020-8030	2445-2448
109. 7620-7630	2323-2326	130. 8040-8050	2451-2454
110. 7640-7650	2329-2332	131. 8060-8070	2457-2460
111. 7660-7670	2335-2338	132. 8080-8090	2463-2466
112. 7680-7690	2341-2344	133. 8100-8110	2469-2472
113. 7700-7710	2347-2350	134. 8120-8130	2475-2478
114. 7720-7730	2353-2356	135. 8140-8150	2481-2484
115. 7740-7750	2359-2362	136. 8160-8170	2487-2490
116. 7760-7770	2365-2368	137. 8180-8190	2493-2496
117. 7780-7790	2371-2374	138. 8210-8220	2502-2505
118. 7800-7810	2377-2381	139. 8230-8240	2509-2512
119. 7820-7830	2384-2387	140. 8250-8260	2515-2518
120. 7840-7850	2390-2393	141. 8270-8280	2521-2524
121. 7860-7870	2396-2399	142. 8290-8300	2527-2530