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A palynological study of the Quaternary succession at Afton Lodge, Scotland

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A palynological study of the Quaternary succession at Afton Lodge, Scotland

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Foreword

This report represents the results and interpretations of a study of the palynology of a Quaternary succession at Afton Lodge, Scotland.

Contents

Summary

The 21 samples from the Afton Lodge Quaternary succession yielded abundant and well-preserved palynofloras, which largely comprise allochthonous Carboniferous spores and indigenous Quaternary sprores/pollen, dinoflagellate cysts and miscellaneous microplankton. Mesozoic/Palaeogene palynomorphs are present in extremely low proportions in eight of the samples.

The reworked Carboniferous spores are extremely prominent in all samples studied and indicate that Carboniferous strata sourced much of this Quaternary clay. They are dominated by *Densosporites* spp. and *Lycospora pusilla*, but other taxa are present in smaller proportions. The Carboniferous assemblages are indicative of the Westphalian Series (Coal Measures), but rare Viséan-Namurian markers were also observed.

Eight samples produced Mesozoic and Palaeogene palynomorphs in extremely small numbers. Most of these are of characteristically Jurassic pollen grains, largely *Callialasporites* spp. It is possible that these forms were derived from the Middle Jurassic of the Hebrides Basin. Single specimens of the Cretaceous dinoflagellate cyst *Odontochitina operculata* and the Palaeogene dinoflagellate cyst *Glaphyrocysta* sp. were also observed. These could be contaminants or they may have been sourced by reworking from the west.

Moderately diverse indigenous Quaternary dinoflagellate cysts were recorded throughout, indicating that marine conditions were fully developed. *Bitectatodinium tepikiense* is the dominant species and represents *c*. 70-90% of the flora. *Achomosphaera andalousiensis* and *Brigantedinium* spp. are also common. This abundance of the low salinity index *Bitectatodinium tepikiense* is unusual and may represent an estuarine setting or freshwater input from melting ice. The overall dinoflagellate cyst and foraminiferal associations both indicate a cold, but not fully glacial environment. The Afton Lodge succession is therefore interpreted as having being deposited in an estuarine setting as opposed to in an ice melt regime; the climate was likely to have been relatively cold, but not glacial. Another hypothesis is that the abundance of *Bitectatodinium tepikiense* indicates a transitional ice melt regime, possibly the melting of Devensian ice. The miscellaneous microplankton observed are entirely consistent with an estuarine setting. Quaternary spores and pollen are also present. Pteridophyte spores are most prominent and indicate the presence of common-abundant ferns and mosses. This assemblage is indicative of damp/wet conditions. Arboreal (tree) pollen is rare and sporadic, indicating that trees were not commonly present close to the site of deposition. Herbaceous pollen is also present in low numbers, thereby indicating low levels of herbaceous plants. The occurrence of *Armeria maritima* suggests a coastal habitat.

The palynofloras are relatively conservative and do not enable this section to be subdivided at fine stratigraphical precision. However, two informally designated zones, A and B have been designated.

1 Introduction

The succession at Afton Lodge comprises approximately 4 m of blue-grey clays of Quaternary age. Occasional pebbles that may be dropstones were observed at the base of the succession. Most of the samples of these blue-grey clays contain shelly fragments including bivalves, echinoid spines and gastropods. Fragments of coal were observed at several horizons, especially at the base and top of the succession. Twenty one samples between elevations 76.92 m and 73.07 m OD were collected for micropalaeontological and palynological analyses. The locality was trenched to allow detailed section description, measuring and sampling. An account of the foraminifera and ostracods was given by Wilkinson (2003). The samples were all prepared using the non-acid technique of Riding and Kyffin-Hughes (2004). Some diatoms were observed in the majority of the samples. These may be significant and consideration should be given to having these silicofossils analysed.

2 Sample Details

Twenty-one samples, MPA 52016 to 52036 were selected from MTD 1941-MTD 1995, between elevations 76.92 and 73.07 m OD, were collected for palynology and calcareous micropalaeontology. The table below lists all 21 samples in this study. The columns represent, respectively, the (informal) sample number, the BGS micropalaeontological registration number (prefixed MPA), the collectors number (prefixed MTD), the elevation in metres and notes pertaining to the macrofossil, coal and pebble content. Lithologically the succession comprises blue-grey clays that are occasionally silty.

1	MPA 52016	MTD 1941	76.92-76.83	bivalve debris
2	MPA 52017	MTD 1944	76.65-76.56	bivalve debris, echinoid spines, coal
3	MPA 52018	MTD 1947	76.38-76.29	bivalve debris, coal
4	MPA 52019	MTD 1949	76.20-76.05	bivalve debris, coal
5	MPA 52020	MTD 1952	75.93-75.88	bivalve debris
6	MPA 52021	MTD 1955	75.78-75.74	
7	MPA 52022	MTD 1958	75.62-75.53	bivalve debris
8	MPA 52023	MTD 1961	75.41-75.35	bivalve debris, echinoid spines
9	MPA 52024	MTD 1964	75.30-75.23	bivalve debris, echinoid spines
10	MPA 52025	MTD 1967	75.09-75.02	bivalve debris, echinoid spines, coal
11	MPA 52026	MTD 1969	74.96-74.90	bivalve debris, echinoid spines
12	MPA 52027	MTD 1971	74.85-74.78	mollusc debris, echinoid spines, coal
13	MPA 52028	MTD 1973	74.71-74.65	entire bivalves and bivalve debris
14	MPA 52029	MTD 1976	74.53-74.47	bivalve debris, coal
15	MPA 52030	MTD 1979	74.35-74.26	bivalve debris, coal
16	MPA 52031	MTD 1982	74.10-74.02	bivalve debris, gastropods
17	MPA 52032	MTD 1985	73.86-73.78	bivalve debris, coal

18	MPA 52033	MTD 1987	73.75-73.67	bivalve debris, coal
19	MPA 52034	MTD 1989	73.58-73.52	bivalve debris
20	MPA 52035	MTD 1991	73.46-73.43	bivalve and fish debris, coal, pebbles
21	MPA 52036	MTD 1995	73.19-73.07	bivalve debris, pebbles

3 Palynology

In this section, the palynofloras are described in three sections. Full listings of palynomorphs, including quantitative data, are held on the respective BGS micropalaeontology/palynology data sheets, all which have been archived.

All the samples produced abundant, well-preserved palynofloras and kerogen associations. The phytoclasts are mainly dark, woody material and plant fragments. Amorphous organic material is rare and was only observed sporadically. Much of the dark wood is interpreted as being derived from Carboniferous material that was incorporated into these sediments. The lighter, more varied plant fragments are interpreted as being indigenous. The palynofloras are largely composed of reworked Carboniferous spores/pollen and Quaternary dinoflagellate cysts and spores/pollen. Mesozoic/Palaeogene palynomorphs are present in extremely low proportions in eight of the samples. A summary of the palynological results is given in Figure 1. Figure 2 is a range chart of the indigenous Quaternary palynomorphs. Despite some differences in the relative proportions of the palynomorph groups, the species spectra are relatively conservative. This indicates that the succession is within the same genetic depositional sequence.

3.1 ALLOCHTHONOUS CARBONIFEROUS SPORES AND POLLEN

Carboniferous spores are extremely prominent in all the samples studied (Figure 1), indicating that Carboniferous strata sourced much of this clay. These associations are overwhelmingly dominated by *Densosporites* spp. and *Lycospora pusilla*. Other prominent Carboniferous forms include *Radiizonates aligerens, Tripartites trilinguis* and *Tripartites vetustus*. Smaller proportions of *Acanthotriletes* spp., *Cirratriradites saturni, Cristatisporites* spp., *Endosporites globiformis, Raistrickia fulva, Raistrickia* spp., *Rotaspora fracta, Simozonotriletes intortus, Triquitrites trivalvis* and *Triquitrites* spp. were also encountered. The majority of this association is indicative of the Westphalian. Specifically, *Cirratriradites saturni, Endosporites globiformis* and *Radiizonates aligerens* are all Westphalian taxa. This is confirmed by the occurrence of coal fragments in these samples (Wilkinson, 2003). However, species such as *Rotaspora fracta* are characteristic of the Viséan-Namurian interval. Therefore the majority of the Carboniferous input is from the Coal Measures and is of Late Carboniferous age. Carboniferous spores and coal fragments were also observed by Wilkinson (2003) in calcareous microfossil residues.

3.2 ALLOCHTHONOUS MESOZOIC/PALAEOGENE PALYNOMORPHS

Between sample numbers 17 to 6, eight samples have yielded Mesozoic and Palaeogene palynomorphs in extremely small numbers (Figure 1). The majority of these occurrences are of typically Jurassic miospores. These comprise *Callialasporites dampieri, Callialasporites microvelatus,* ?*Callialasporites turbatus, Cerebropollenites macroverrucosus, Classopollis meyeriana* and *Classopollis* spp. All these taxa were recovered in samples 17 to 11 (Figure 1). This association is relatively long ranging, however *Callialasporites* and *Cerebropollenites* are most common in the Jurassic. *Callialasporites* spp. are indicative of derivation from Middle or Upper Jurassic strata (Riding et al., 1991). No exclusively Cretaceous miospores such as *Cicatricosisporites* were encountered. It is possible that these grains were transported from a

Middle Jurassic depocentre such as the Hebrides Basin. One specimen of the distinctive Cretaceous dinoflagellate cyst *Odontochitina operculata* was observed in sample 6. This form may have been derived from the west; the Chalk Group is developed in Northern Ireland. A single specimen of the typically Palaeogene dinoflagellate cyst genus *Glaphyrocysta* was recorded from sample 9. This is either an abberant contaminant or it was derived from the offshore area. The extremely rare nature of these Mesozoic and Palaeogene forms may indicate the possibility of contamination. This is deemed unlikely, especially for the Jurassic miospores. This is due to the similarity of the floras and the fact that the Jurassic reworking is confined to a specific stratigraphical interval.

3.3 INDIGENOUS QUATERNARY PALYNOMORPHS

The indigenous Quaternary palynomorphs are described in three subsections, i.e. dinoflagellate cysts, miscellaneous microplankton and spores/pollen.

3.3.1 Dinoflagellate cysts

Dinoflagellate cysts characteristic of the Quaternary are present throughout (Figures 1, 2). Taxa represented include *Achomosphaera andalousiensis, Bitectatodinium tepikiense, Brigantedinium simplex, Brigantedinium* spp*., Lingulodinium machaerophorum, Operculodinium centrocarpum, Selenopemphix quanta, Spiniferites mirabilis, Spiniferites ramosus* and *Spiniferites* spp. These forms indicate that marine conditions were fully developed throughout. *Bitectatodinium tepikiense* is the dominant species. Typically it accounts for over 100 specimens per microscope slide; this represents around 70-90% of the entire dinoflagellate cyst flora. *Achomosphaera andalousiensis* and *Brigantedinium* spp. are also common. The other forms are relatively rare.

This superabundance of *Bitectatodinium tepikiense* is extremely unusual and there is no modern analogue of this situation. *Bitectatodinium tepikiense* is present in cold temperate to sub-Arctic environments today (Dale, 1996, fig. 2) and is common off the east coast of Canada (Rochon et al., 1999, fig. 14). It requires a summer temperature of at least 10ºC and it can tolerate a wide variety of salinities, but is common in low salinity conditions (Dale, 1985; Bakken and Dale, 1996; Duane and Harland, 1990; Harland, 1994). Therefore, it may be common close to estuaries, or where there is freshwater input via melting ice. It may thus be viewed as an index of either major drainage centres or ice melting events. The latter therefore indicates a transition from cold to temperate conditions. The occurrence of large numbers of *Bitectatodinium tepikiense* and *Brigantedinium* spp. (including *Brigantedinium simplex*) and the relatively small proportions of *Operculodinium centrocarpum* suggests a relatively cold environment (Harland, 1992). However, the presence, in relatively small numbers, of *Selenopemphix quanta* and *Spiniferites mirabilis,* confirms that this was not a fully glacial environment. These species are known to be warmer water indices (Rochon et al., 1999). This overwhelming dominance of *Bitectatodinium tepikiense* appears to indicative a unique environment. The proportions of *Bitectatodinium tepikiense* are far greater than, for example, at the mouth of the Gulf of St.Lawrence, eastern Canada today (Rochon et al., 1999, fig. 14). However, it may attain 60-80% of the assemblage in bays off Nova Scotia, Canada (Mudie, 1990) and Maine (Wall et al., 1977). Based on the occurrence of abundant *Bitectatodinium tepikiense* with *Brigantedinium* spp. and low numbers of the relatively warm water *Operculodinium centrocarpum*, *Selenopemphix quanta* and *Spiniferites mirabilis* and certain relatively warm water foraminifera (Wilkinson, 2003), this succession is interpreted as having being deposited in a nearshore estuarine setting, as opposed to in an ice melt regime. The climate was likely to have been relatively cold, but not glacial. An ice melt scenario would not have yielded any warmer water forms. Nevertheless, an alternative hypothesis is that the abundance of *Bitectatodinium tepikiense* is a proxy for a transitional ice melt regime, possibly the melting of Devensian ice, *c*. 10,000 years ago because of the low-salinity nature of this species. In the Holocene, *Bitectatodinium tepikiense* is normally found together with high proportions of *Operculodinium*

centrocarpum and in the Devensian it is normally subordinate to *Brigantedinium* spp. (e.g. Stoker at al., 1991, fig. 8). *Lingulodinium machaerophorum* is a neritic taxon and is consistent with a relatively nearshore setting, which is consistent with the evidence from spores (see section 3.3.3).

3.3.2 Miscellaneous microplankton

Relatively small proportions of miscellaneous microplankton were observed throughout (Figures 1, 2). These comprise *Botryococcus* (freshwater/brackish algae), *Pediastrum* (freshwater alga) and *Tasmanites* (marine prasinophycean alga) (Figures 1, 2). All these forms are interpreted as being indigenous. *Botryococcus* and *Pediastrum* are assumed to have been introduced into the marine environment by the same drainage system that transported the spores and pollen grains and are consistent with an estuarine setting. *Tasmanites* is characteristic of nearshore settings. These forms are not precise stratigraphical indices.

3.3.3 Spores and pollen

Quaternary spores and pollen are consistently present (Figures 1, 2). The relative proportions and the species spectra are similar throughout. Pteridophyte spores are consistently prominent and include *Laevigatosporites*, *Lycopodium, Polypodium, Selaginella selaginoides, Sphagnum* and undifferentiated spores. This assemblage is indicative of the presence of common to abundant pteridophytes (see Appendix 1). These include ferns (*Polypodium*), Lesser Clubmoss (*Selaginella selaginoides*), peat/bog moss (*Sphagnum*) and occasional club mosses (*Lycopodium*) (Appendix 1). This association is indicative of damp/wet conditions and acidic soil. The presence of *Sphagnum* indicates a boggy setting. The presence of *Erica* (Heather) pollen is entirely consistent with an upland habitat that may be damp in places.

The most abundant arboreal (tree) pollen is *Pinus* (Figure 2). This bisaccate pollen can travel long distances and does not necessarily indicate the presence of Pine trees in the immediate vicinity. Other arboreal pollen is rare and sporadic in occurrence; it includes *Alnus* (Alder), *Betula* (Birch), *Corylus* (Hazel) and *Picea* (Spruce). The rarity of arboreal pollen indicates that trees were not commonly present close to the site of deposition.

Herbaceous pollen is also present sporadically and in low numbers in this succession (Figure 2). These include representatives of the Asteraceae (daisies, dandelions and thistles, formerly Compositae), Caryophyllaceae (chickweeds, stitchworts and campions) and *Armeria maritima* (Thrift or Sea Pink). The relatively low numbers of these pollen types indicates the presence of low numbers of herbaceous plants. The occurrence of *Armeria maritima* (type B) suggests proximity to the coastline. The Family Plumbaginaceae (Leadwort Family) typically prefer coastal habitats.

These spore/pollen floras are consistent with a relatively cold, coastal environment.

4 The subdivision of the succession into informal zones

Wilkinson (2003) subdivided this succession into seven informal assemblage zones (A to G inclusive) on the basis of differences in the foraminiferal associations. The palynofloras do not exhibit stratigraphically significant changes to enable this section to be subdivided at this level of precision. Analysis of the taxonomic spectra, productivity and diversity, however, indicate the presence of two informally designated zones. These zones are termed A and B; Zone A comprises samples 14 to 1 and zone B is represented by samples 21 to 15.

4.1 ZONE B (SAMPLES 21-15)

Samples 21 to 15 are not as palynologically productive as the samples in Zone A, with the majority of the samples having *c*. 400 grains per slide (Figure 1). The variation is 405 grains (sample 17) to 802 palynomorphs (sample 16). Furthermore, the diversity of both spores/pollen and microplankton is markedly lower in this zone than Zone A (Figure 2). In particular, the dinoflagellate cyst floras are especially low in diversity in Zone B. These comprise *Achomosphaera andalousiensis, Bitectatodinium tepikiense, Brigantedinium simplex* and *Brigantedinium* spp., which possibly indicate colder conditions in this, the lowermost part of this succession.

4.2 ZONE A (SAMPLES 14-1)

With the exception of sample 13, which produced 462 palynomorphs per slide, samples 14 to 1 inclusive were relatively abundant (Figures 1, 2). They vary from 612 grains (sample 1) to 1336 grains (sample 9) (Figure 1). Palynomorph diversity is relatively high in samples 14 to 1 (Figure 2). The dinoflagellate cysts in this interval are significantly more diverse than in Zone B. *Lingulodinium machaerophorum, Operculodinium centrocarpum, Selenopemphix quanta, Spiniferites mirabilis, Spiniferites ramosus* and *Spiniferites* spp. are all present in this interval (Figure 1). This may represent some climatic warming in this interval. By contrast, the dinoflagellate cyst floras in Zone B comprise *Achomosphaera andalousiensis, Bitectatodinium tepikiense, Brigantedinium simplex* and *Brigantedinium* spp. However, *Lingulodinium machaerophorum* was recorded in sample 15 (Figure 2). There is less of a difference in spore/pollen diversity between the zones, however both arboreal and herb pollen is more diverse in Zone A (Figure 2).

5 Comparison of the palynological results with the calcareous microfossil evidence

Wilkinson (2003) reported on the calcareous microfaunas (foraminifera and ostracods) from the same Afton Lodge samples that were studied here. Planktonic foraminifera are virtually absent, therefore indicating a neritic setting. The benthic foraminifera and ostracods indicate a cold, shallow, fully marine environment of deposition. Evidence of estuarine conditions was also observed. These findings are entirely consistent with the palynological results.

Both calcareous microfaunas and palynology indicate that the source of much of the Afton Lodge sediment is from presumably local Middle and Upper Carboniferous strata. The two disciplines also confirm the environment of deposition was a nearshore, shallow, estuarine setting in a relatively cold climate. It is possible that the succession represents part of the late Devensian phase of deglaciation, which could probably be tested by AMS Carbon dating.

6 Conclusions

The 21 samples from the Afton Lodge Quaternary succession yielded abundant and well-preserved palynofloras, which largely comprise allochthonous Carboniferous spores and indigenous Quaternary sprores/pollen, dinoflagellate cysts and miscellaneous microplankton. Mesozoic/Palaeogene palynomorphs are present in extremely low proportions in eight of the samples.

The reworked Carboniferous spores are extremely prominent in all samples studied and indicate that Carboniferous strata sourced much of this Quaternary clay. They are dominated by

Densosporites spp. and *Lycospora pusilla*, but other taxa are present in smaller proportions. The Carboniferous assemblages are indicative of the Westphalian Series (Coal Measures), but rare Viséan-Namurian markers were also observed.

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The palynofloras are relatively conservative and do not enable this section to be subdivided at fine stratigraphical precision. However, two informally designated zones, A and B have been designated.

Appendix 1 A description of the environmental preferences of selected pteridophytic plants represented in this study.

This Appendix lists the affinities and ecological preferences of four of the principal pteridophyte plants represented by spores in this study; it refers to section 3.3.3.

Lycopodium = club moss. These plants prefer cool, damp, shaded thickets; moist woods, bogs, meadows etc., with acidic soils which are well to poorly drained. May occasionally live in dry, exposed, and rocky environments. It is also characteristic of boreal coniferous forests.

Polypodium = ferns. Mostly evergreen ferns which are widespread. They frequently grow in rock crevices or on rock ledges, and prefer partial shade and a humus-rich, acidic soil.

Selaginella selaginoides = Lesser Clubmoss. A small creeping clubmoss, with upright cone-bearing branches, found in wet environments, often close to springs where the ground is not especially acidic. Common in hilly and mountain districts.

Sphagnum = peat/bog mosses.

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Sample	Palynomorphs	Informal	Carboniferous	Mesozoic/	Quaternary			
No.	per slide	Zone	miospores	Palaeogene	Total Q. palys.	Q. mios.	Q. d. cysts	Q. misc. mp
1	612	A	292 (47.7%)	…	320 (52.3%)	57 (9.3%)	255 (41.7%)	8 (1.3%)
2	1040	A	425 (40.9%)	…	615 (59.1%)	73 (7.0%)	520 (50.0%)	22 (2.1%)
3	812	A	318 (39.2%)	…	494 (60.8%)	51 (6.3%)	429 (52.8%)	14 (1.7%)
4	803	A	594 (74.0%)	…	209 (26.0%)	47 (5.8%)	131 (16.3%)	31 (3.9%)
5	1225	A	774 (63.2%)	…	451 (36.8%)	134 (10.9%)	287 (23.4%)	30 (2.5%)
6	1090	A	613 (56.2%)	1 (0.1%)	476 (43.7%)	157 (14.4%)	288 (26.4%)	31 (2.9%)
7	1207	A	692 (57.3%)	…	515 (42.7%)	92 (7.6%)	394 (32.7%)	29 (2.4%)
8	1050	A	449 (42.8%)	…	601 (57.2%)	37 (3.5%)	540 (51.4%)	24 (2.3%)
9	1336	A	511 (38.2%)	1 (0.1%)	824 (61.7)	102 (7.6%)	693 (51.9%)	29 (2.2%)
10	1023	A	251 (34.3%)	…	672 (65.7%)	151 (14.8%)	489 (47.8%)	32 (3.1%)
11	764	A	220 (28.8%)	3 (0.4%)	541 (70.8%)	85 (11.1%)	456 (59.7%)	…
12	994	A	362 (36.4%)	1 (0.1%)	631 (63.5%)	127 (12.8%)	504 (50.7%)	…
13	462	A	124 (26.8%)	…	338 (73.2%)	38 (8.2%)	297 (64.3%)	3 (0.7%)
14	700	A	261 (37.3%)	4 (0.6%)	435 (62.1%)	85 (12.1%)	315 (45.0%)	35 (5.0%)
15	458	B	217 (47.4%)	1 (0.2%)	240 (52.4%)	71 (15.5%)	149 (32.5%)	20 (4.4%)
16	802	B	420 (52.4%)	3 (0.4%)	379 (47.2%)	63 (7.8%)	287 (35.8%)	29 (3.6%)
17	405	B	261 (64.4%)	?1 (?0.3%)	143(35.3%)	56 (13.8%)	87 (21.5%)	…
18	453	B	338 (74.6%)	…	115 (25.4%)	41 (9.1%)	48 (10.6%)	26 (5.7%)
19	454	B	309 (68.1%	…	145 (31.9%)	40 (8.8%)	72 (15.8%)	33 (7.3%)
20	694	B	526 (75.8%)	…	168 (24.2)	76 (11.0%)	62 (8.9%)	30 (4.3%)
21	490	B	317 (64.7%)	…	173 (35.3%)	69 (14.1%)	100 (20.1%)	4 (0.8%)

Figure 1. The palynomorphs recovered per slide and the numbers and percentages of Carboniferous, Mesozoic/Palaeogene and Quaternary palynomorphs in the samples studied from Afton Lodge.

(INFORMAL) SAMPLE NUMBER	SAMPLE NUMBER (MPA)	COLLECTOR'S NUMBER (MTD)	SAMPLE ELEVATION (m)	INFORMAL ZONE	SPORES AND POLLEN: SPORES: fungal spores	*Laevigatosporites*	*Lycopodium*	*Polypodium*	*Selaginella selaginoides*	*Sphagnum*	spores - undifferentiated	POLLEN: *Alnus*	*Armeria maritima* type B	*Aster*	*Betula*	Caryophyllaceae	*Compositae*	*Corylus*	*Erica*	*Picea*	*Pinus*	pollen - indeterminate	tricolpate pollen	SIMPLE DIVERSITY	DINOFLAGELLATE CYSTS: *Achomosphaera andalousiensis*	*Bitectatodinium tepikiense*	*Brigantedinium simplex*	*Brigantedinium* spp.	dinoflagellate cysts- indeterminate	*Lingulodinium machaerophorum*	*Operculodinium centrocarpum*	*Selenopemphix quanta*	*Spiniferites mirabilis*	*Spiniferites ramosus*	*Spiniferites* spp.
1	52016	1941	76.92-76.83			●			▮	▮	●						●		●	●	●		●	9	▮	★		▮			●		●		●
2	52017	1944	76.65-76.56		●			▮	●		●			●				●	●	●	▮	●		11	▮	★		▮	●						●
3	52018	1947	76.38-76.29		●	▮				●	●									●	▮	●	●	8	▮	★		▮							
4	52019	1949	76.20-76.05			▮			●	●	●				●						▮	●		6	▮	★		▮							●
5	52020	1952	75.93-75.88			▮		●	▮	●	●	●					▮	▮		●	▮	●	●	12	▮	★		▮	●		●	●	●	▮	
6	52021	1955	75.78-75.74			▮		●	▮	▮	●	●	●				▮			●	▮	▮	●	12	▮	★		▮			●	●			▮
7	52022	1958	75.62-75.53			▮	●	●	▮	▮	●		●	●			●				▮			10	▮	★		▮			▮		●	●	●
8	52023	1961	75.41-75.35	A		●		●	▮		●		●			●						●		7	★	★		▮			●	●			▮
9	52024	1964	75.30-75.23			▮		●	▮	▮	▮		●								▮	●		8	▮	★		★			●	●	●		▮
10	52025	1967	75.09-75.02		●	▮		▮	▮		▮		●						●		▮	●		10	▮	★		★			▮	●	●		▮
11	52026	1969	74.96-74.90			▮		●	▮												▮	●		6	★	★	●	▮		●	▮	●	●		▮
12	52027	1971	74.85-74.78			▮		▮	▮	▮	▮	●	●	●			●		●		▮	●		12	★	★	●	▮		●	▮	●	●	▮	▮
13	52028	1973	74.71-74.65							▮	●			●							▮			4	★	★		▮		●	▮	●	▮		▮
14	52029	1976	74.53-74.47			▮		●	▮	▮	▮										▮			6	▮	★		▮		●			●		▮
15	52030	1979	74.35-74.26		●	▮		●	●				●	●			●				▮			9	▮	★		▮		●					
16	52031	1982	74.10-74.02			▮		●	●	▮			●								▮		●	7	●	★		▮							
17	52032	1985	73.86-73.78			▮		●	●				●								▮			5		★	●	▮							
18	52033	1987	73.75-73.67	B		▮		●													▮			3		▮									
19	52034	1989	73.58-73.52			▮			●				●				●				▮			5	●	★		▮							
20	52035	1991	73.46-73.43			▮		●	▮				●								▮			5	●	▮		●							
21	52036	1995	73.19-73.07		●	▮		●			●		●												▮	★		▮							

● < 10 specimens
▮ 10 -50 specimens
★ > 50 specimens

Figure 2. Quaternary palynomorph range chart of the Afton Lodge section.