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Preliminary investigations of the diatom stratigraphy of Borehole TA8, Portage Alaska

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Aim

This report presents the results of diatom analyses of nine samples taken from Borehole TA8 at Portage, Alaska. Borehole TA8 was drilled in 1988, with the lithology and radiocarbon ages reported shortly afterwards (Combellick, 1991). The aim of this preliminary investigation is to ascertain the degree of preservation of fossil diatoms in Borehole TA8, using very small samples of sediment, and so inform decisions regarding the likely benefits of a comprehensive study of the whole sequence.

Methods

In order to minimise disturbance of the archived cores we sampled across two of the peat layers radiocarbon dated by Combellick (1991). First, a well developed peat with a sharp upper contact, thought to represent the penultimate great earthquake ~900 years ago that produced coseismic subsidence and rapid marsh submergence. Second, a poorly defined peat layer, at a much greater depth than any cores from upper Cook Inlet previously analysed for their fossil diatom content. Appendix 1 gives the diatom counts for each of the samples and Appendix 2 shows images of some of the species identified. Appendix 3 gives the original core logs and notes on the samples taken for diatom analysis and Appendix 4 the procedures used.

Interpretation

All samples show sufficient preservation of identifiable fossil diatoms to justify further analyses. There are sufficient numbers present to give statistically reliable counts and the species are similar to those recorded in modern samples from marshes around upper Cook Inlet, suggesting that quantitative transfer function methods will have a high probability of success in providing reconstructions of relative land/sea level changes (Hamilton and Shennan, 2005).

The sharp upper contact of the peat layer dated ~900 years ago has an abrupt change in diatoms across the lithologic boundary. Sample 2, at the top of but within the peat, has an assemblage dominated by freshwater and salt-intolerant species, especially *Eunotia* spp., whereas sample 1, from the base of the silt layer directly above has a marine and brackish assemblage, dominated by *Delphineis surirella* and *Paralia sulcata*.

The two lowest samples, 8 and 9, are above and below a poorly defined peat layer that we did not sample in order to not disturb the thin organic sediment for this preliminary investigation. Both samples 8 and 9 contain marine and brackish diatoms, along with species that suggest significant freshwater input into a tidal flat environment.

Conclusions

Fossil diatom abundances in all of the samples suggest that it will be worthwhile to analyse the complete sequence in order to correlate the record of seismic and non-seismic relative land and sea level changes in Turnagain Arm. Given that Borehole TA8 from Portage and TA1 from Girdwood (Combellick, 1991) have records that span more than 10,000 years they potentially provide a unique study as we currently have a record of earthquake cycles for only the last 4000 years (Shennan et al., 2008).

References (including those cited in Appendices)

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Appendix 1

Diatom counts.

See Appendix 4 for explanation and limitations of diatom classifications

Portage core samples: note depths are those measured during sampling from the archived cores July 15, 2010

Core	TA8-4	TA8-4	TA8-4	TA8-4	TA8-4	TA8-4	TA8-4	TA8-12B	TA8-12B
Slide	7	1	2	3	4	5	6	8	9
Depth (m)	3.81	3.84	3.85	3.86	3.9	4.01	4.03	12.61	12.65
Depth (ft)	12.50	12.60	12.63	12.66	12.80	13.16	13.22	41.37	41.50
Summary lithology	Silt	Silt	Peat	Peat	Peat	Peat base	Silt	Silt	Silt
Marine (Polyhalobous)									
Actinoptychus senarius	6	8				1	2	11	20
Delphineis surirella	107	110	6	2	54	7	11	115	98
Navicula pennata	1								
Nitzschia insignis	1								
Odontella aurita		4			1		2		
Paralia sulcata	68							10	10
Rhabdonema minutum	1								
Surirella fastuosa								1	3
Thalassiosira eccentrica	3					1	1	53	3
Triceratium favus	1								
Brackish (Mesohalobous)									
Amphora commutata	1								
Caloneis westii								6	
Cocconeis diminuta		11			3				
Cyclotella striata	4							91	16
Diploneis smithii								3	
Navicula peregrina	2	18						12	6
Nitzschia brevissima							1		
Nitzschia obtusa						15	2	18	28
Nitzschia sigma	15								
Rhopalodia brebissonii									53
Fresh Brackish (Oligohalobian Halophile)									
Cyclotella meneghiniana		75			6	3	10	72	33
Navicula cari var. cincta	11								
Pinnularia aestuarii							1		
Pinnularia krockii				17	23	12	2	54	4
Thalassiosira fluviatilis							1		

Continued:

Fresh (Oligohalobian Indifferent)

Caloneis bacillum	1								
Cymbella minuta						9	39	7	
Cymbella sinuata							3		
Epithemia zebra	1	1							
Eunotia flexuosa			13	4	4				
Eunotia pectinalis	1								
Eunotia perpusilla		1							
Eunotia repens						5			
Eunotia valida			14	22					
Eunotia ventricosa			2						
Gomphonema gracile							4		
Gomphonema ventricosum	1								
Navicula brockmanii	1								
Navicula capitata			2						
Navicula menda		2							
Navicula tripunctata	1								
Navicula variostriata				2	1		4	1	
Neidium clavum						12	5		
Nitzschia fruticosa					1	12	19	8	3
Nitzschia linearis								5	
Nitzschia paleacea	10							3	43
Pinnularia angusta						2			
Pinnularia borealis	1								
Pinnularia brevicostata			2	1		12	12		6
Pinnularia mesolepta							2		
Pinnularia microstauron						8	26	3	
Pinnularia sublanceolata							1		
Pinnularia sudetica	1								
Pinnularia viridis						16	35	42	
Stauroneis anceps								4	
Staurosira elliptica	1							48	23
Staurosirella pinnata	8							2	

Fresh (Oligohalobian halophobe)

Cyclotella antiqua								3	
Eunotia arcus		1	104	136	36	64	16	2	
Eunotia exigua					86				
Eunotia praerupta			60	55	40	13	9		
Frustulia rhomboides	1								
Pinnularia subcapitata		6			1	43	16		
Staurosirella leptostauron	2						1		
Tabellaria flocculosa						11	9		1
Tabellaria fenestrata		5		9		2	32		1

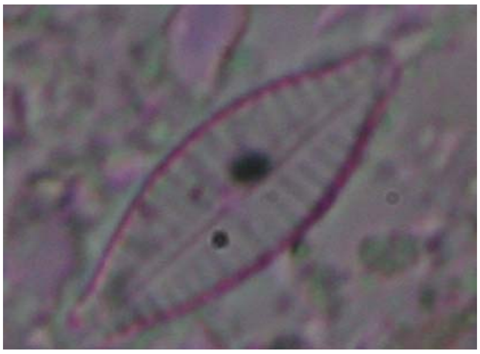
Unknown

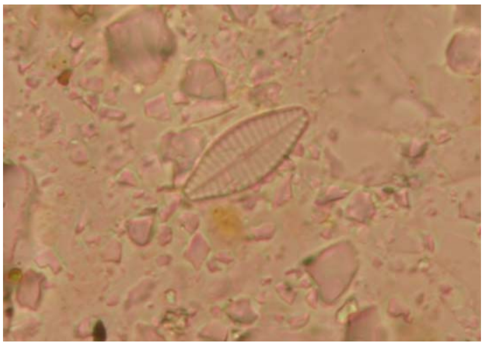
Pinnularia quadratarea?							5		

Appendix 2

Images of selected diatom species found in Borehole TA8. Actual images from either TA8 or other samples from Alaska boreholes.

Achnanthes delicatula

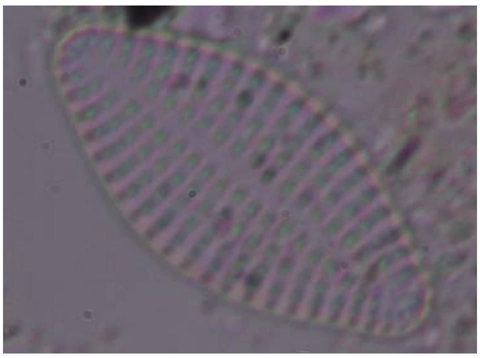


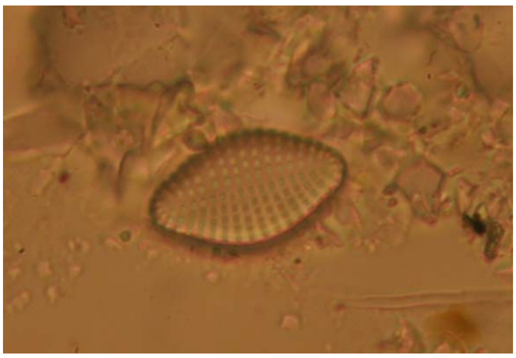


Actinoptychus senarius

Cyclotella striata

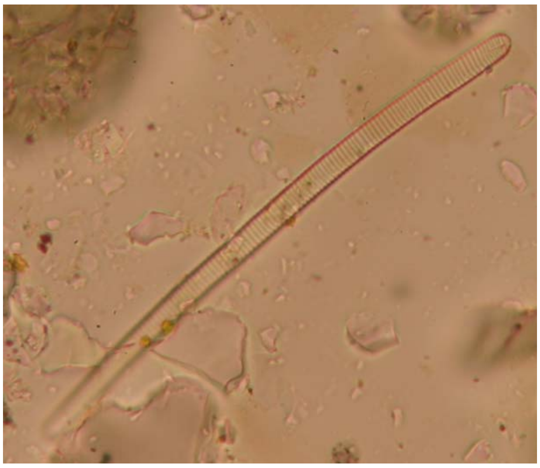
Delphineis surirella



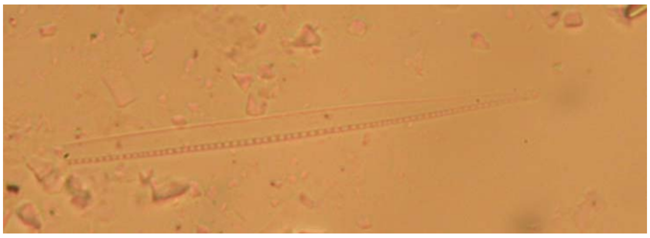


Eunotia arcus (left) & *E. exigua*

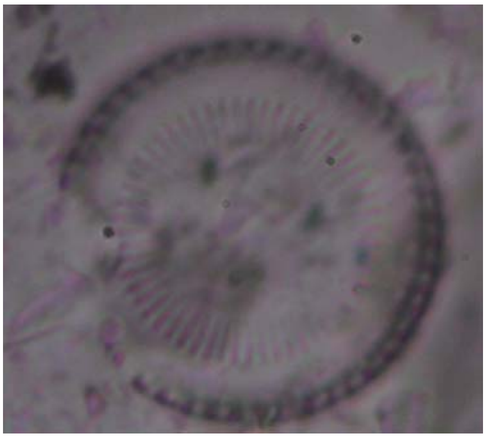
Eunotia lunaris



Nitzschia fruticosa

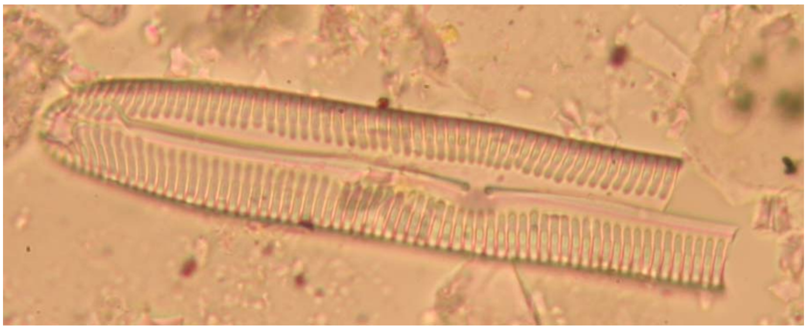


Paralia sulcata

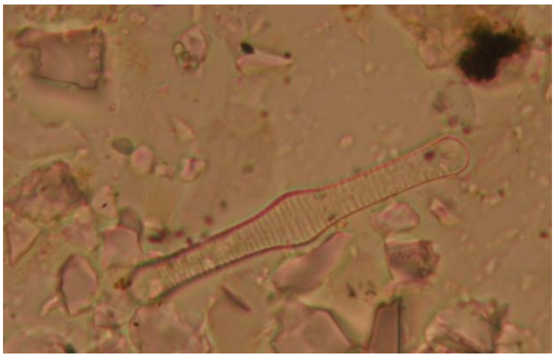


Pinnularia subcapitata

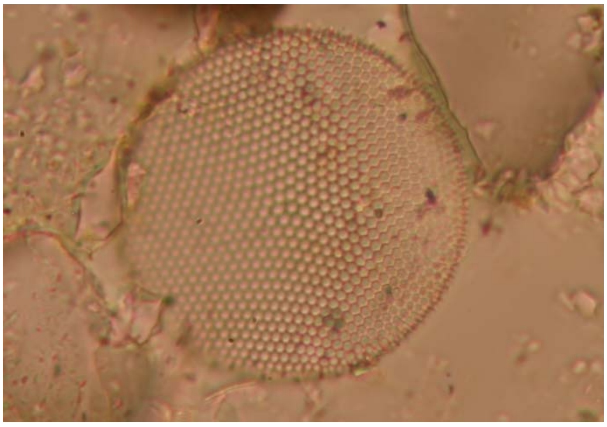
Pinnularia viridis



Tabellaria fenestrata (left) and T. Flocculosa




Thalassiosira eccentrica



Appendix 3

Original core logs, from Combellick (1991)

TA8-4	11.0-11.85	Gray silt, silty fine sand, and clean fine sand in contorted zones; probably disturbed during sampling. Some evidence of lamination at 11.4. Negligible organics. Minor iron staining.
	11.85-12.6	Gray to brownish gray clayey silt and fine sandy silt. Disseminated organics 12.1-12.3. Scattered sedge blades. Spl TA8-4-12.5 at 12.4-12.6 (GS).
	12.6-13.25	Brown to dark brown sedge and woody peat. Increasing silt toward base. Sharp upper contact. Spl TA8-4-12.7 at 12.6-12.75 (C14).
	13.25-13.4	Brownish gray organic-rich silt.

Radiocarbon sample GAX-15218: 885±120 BP

TA8-12B	41.0-41.4	Gray laminated silt and silty fine sand. No visible organics.
	41.4-41.55	Gray to brownish gray silt with thin layers of organic material. Possibly a buried peat layer. Spl TA8-12B-41.5 at 41.4-41.55 (C14).
	41.55-43.5	Gray to brownish gray silt with scattered organics and very faint laminations in lower 1.0 ft. No distinct upper contact. Distorted organic zone (sedge?) at 42.3.

Radiocarbon sample GAX-15223: 4150±130 BP

Note: the depths above are in feet, those reported in Appendix 1 are in meters, and are the depths measured during sampling on July 15, 2010. There may be slight differences to the depths of boundaries due to the core drying out during storage.

Samples taken, July 2010

Core	TA8-4	TA8-4	TA8-4	TA8-4	TA8-4	TA8-4	TA8-4	TA8-12B	TA8-12B
Slide	7	1	2	3	4	5	6	8	9
Depth (m)	3.81	3.84	3.85	3.86	3.9	4.01	4.03	12.61	12.65
Depth (ft)	12.50	12.60	12.63	12.66	12.80	13.16	13.22	41.37	41.50
Summary lithology	Silt	Silt	Peat	Peat	Peat	Peat base	Silt	Silt	Silt

Appendix 4:

Diatom methods

Preparation of diatom samples followed standard laboratory methods (Palmer and Abbott, 1986) with a minimum count of 250 diatom valves possible for most samples. With only very small amounts of sediment taken from the archive cores we could not experiment with different densities of residue on the slides, therefore we have found it better to use, where appropriate, photographs taken from other cores in Alaska that we have studied.

The two key reference volumes for coastal and estuarine diatoms are based on NW European material (Hartley et al., 1996; Van der Werff and Huls, 1958-1974) together with supplementary information from the Pacific Northwest (Hemphill-Haley, 1993) and flora of north American freshwater species (Patrick and Reimer, 1966; Patrick and Reimer, 1975).

In broad terms, the order of diatom salinity classes (Appendix 1) should reflect change from tidal flat through tidal marsh, to freshwater marsh and bog. Marine (polyhalobous) and brackish (mesohalobous) groups usually dominate tidal flat environments and freshwater groups tolerant of different degrees of salinity (oligohalobous-halophile and oligohalobous-indifferent) become dominant through the transition from tidal marsh to freshwater marsh. Salt-intolerant species (halophobous) characterise the most landward communities, including those from acidic bogs above the level of highest tides.

The summary salinity classes were originally defined in the studies in NW Europe. Samples from upper Cook Inlet show that the environmental tolerances of a number of species are much broader. For example *Navicula cari* var *cincta*,*Tabellaria fenestrata* and *T.flocculosa* are classified within different freshwater groups (Appendix 1) yet we have found them across tidal marshes and tidal flat locations around upper Cook Inlet (Hamilton and Shennan, 2005).