Reports

Grand Banks and J-Anomaly Ridge: A Geological Comparison

Abstract. *Geological and geophysical evidence supports the hypothesis that the J-anomaly ridge was a part of the Grand Banks in (late) Early Cretaceous time.*

The J-anomaly ridge, immediately south of the Grand Banks in the northwestern Atlantic Ocean, is associated with a high-amplitude magnetic anomaly which may be correlated with the youngest of the Keathley sea-floor spreading lineations (*1, 2*). Basalt cored at the bottom of Deep Sea Drilling Project (DSDP) site 384 (Fig. 1) on the ridge has been taken as oceanic basement, and the discovery of Lower Cretaceous reefal carbonates, immediately overlying the basalt, has been interpreted as evidence that the ridge has subsided more than 4100 m since Early Cretaceous time, "making this the most deeply subsided former island yet drilled in the ocean basin" (*1*).

Geological and geophysical studies of the Grand Banks region support an alternative interpretation of the stratigraphy and geological history of the abyssal J-anomaly ridge in the vicinity of DSDP site 384, suggesting that (i) the J-anomaly ridge carbonates are part of a Grand Banks late Early Cretaceous "carbonate platform," (ii) the basalts penetrated on the J-anomaly ridge may be coeval with mafic lava flows on the Grand Banks, (iii) the J-anomaly ridge basement (?) seismic event may be correlated with the Grand Banks Early Cretaceous unconformity, and (iv) total subsidence of the southern Grand Banks and J-anomaly ridge is of comparable magnitude since late Early Cretaceous time.

The geological history of the Grand Banks off Newfoundland is relatively well known from more than 20 core holes and 40 exploratory wells drilled between 1965 and 1974 in this region. Paleozoic metasedimentary and igneous rocks beneath the Grand Banks form a basement which is covered by Mesozoic and Cenozoic sedimentary deposits (*3–5*). These include a conformable sequence of Upper Triassic red beds and evaporites, Lower Jurassic evaporites and marine shales, and Middle and Upper Jurassic marine shales with subordinate sandstones and limestones. An angular unconformity, which is most prominent on the central part of the Grand Banks and disappears southward, separates Upper Jurassic strata from overlying upper Lower Cretaceous sediments. The tectonism that occurred in the Early Cretaceous was accompanied by volcanism, with extrusions of basaltic flows and trachytes on the southern Grand Banks at the Amoco Imp Skelly Mallard M-45 well (*6, 7*) (Fig. 1) and on the southern Labrador Shelf at the wells Eastcan Leif M-48 and Bjarni H-81 (*8*). Nonmarine and shallow marine clastics and carbonates of Aptian to Albian age were deposited over the Grand Banks unconformity surface, followed by deeper marine fine, terrigenous clastics with rare chalks, deposited during Late Cretaceous and Tertiary time. Quaternary deposits are again of a marginal marine nature. The Mesozoic and Cenozoic sedimentary sequence of the Grand Banks forms a wedge that increases in thickness toward the present shelf edge, where it locally reaches a thickness of 10 km (*5*). A minimum thickness of the continental crust beneath the slope off the southern Grand Banks, based on refraction measurements (*9*), is 26 km.

Two wells drilled near the southern Grand Banks shelf edge (Fig. 1) bottomed in Lower Cretaceous strata. The Amoco IOE Puffin B-90 well, located over a deep salt structure, penetrated 4565 m of Cenozoic and upper Mesozoic sediments (*10*) (Fig. 2); it bottomed in Neocomian (Berriasian) beds. The nearby Amoco Imp Skelly Tern A-68 well, drilled on a slightly shallower salt structure, penetrated 4044 m of Cenozoic and upper Mesozoic sediments (*10, 11*) (Fig. 2); it also bottomed in Neocomian (Berriasian) beds. In both wells the Lower Cretaceous strata are paralic to shallow marine, grading into Upper Cretaceous deposits of more open marine, deeper shelf facies. Paleocene to early Miocene deposition occurred in a bathyal (slope) environment, with younger strata reflecting return to a shallower shelf environment.

Deposition rates of up to 10 cm per 1000 years prevailed during Neocomian time at the Puffin site and during the late Cenozoic in both the Puffin and Tern wells (Fig. 3). The high deposition rate recorded in Neocomian time is thought to be related to a high sediment supply from the uplifted central Grand Banks. The rapid late Cenozoic sedimentation is interpreted as an increase in sediment supply due to a major regressive phase, which had been preceded during Maastrichtian to Eocene time by a major transgression that resulted in partial sediment starvation of areas distant from the shoreline.

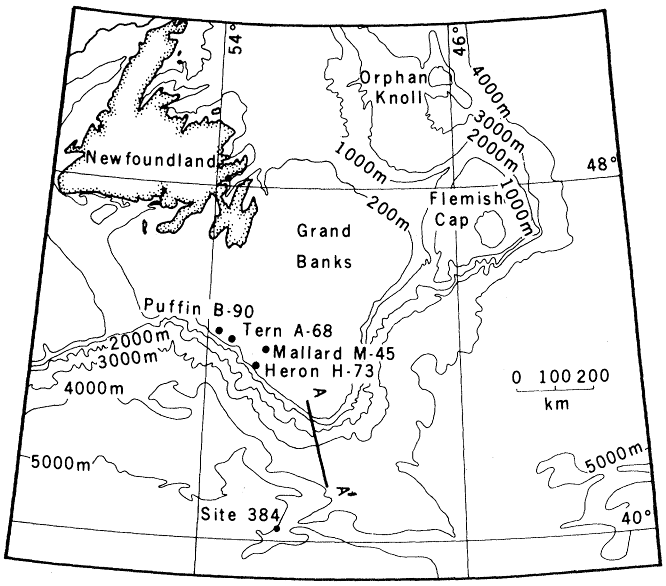
Deep Sea Drilling Project site 384, at a depth of 3910 m on the J-anomaly ridge south-southeast of the Grand Banks (Fig. 1), bottomed at 330.3 m below the sea floor in altered diabasic basalt, which was interpreted by Tucholke *et al.* (*1*) as oceanic basement. Immediately overlying the basalt is more than 125 m of Lower Cretaceous to Aptian carbonates composed of rudists and chamids together with gastropods, corals, echinoids, and orbitolinid foraminifers enclosed in a micritic matrix. The limestone is overlain by marl of Coniacian-Santonian (?) age, followed by pelagic zones of Maastrichtian to Middle Eocene age (Fig. 2). The estimated rate of sedimentation for the Cretaceous is almost the same as for the Cenozoic and amounts to approximately 0.3 cm per 1000 years, which is several times lower than the coeval rates on the southern Grand Banks (Fig. 3).

Figure 4 is a plot of subsidence since Barremian time at site 384 and at the Puffin and Tern wells, and total subsidence since Berriasian time at the Puffin well, based on the depth below the sea floor plus the present water depth. The total subsidence curves for the Puffin well and site 384 are almost parallel. The divergence of the curves when the Barremian is used as the initial subsidence point probably reflects salt movement, which altered subsidence in the Puffin and Tern wells.

The Aptian limestone cored at site 384 resembles carbonate from other parts of

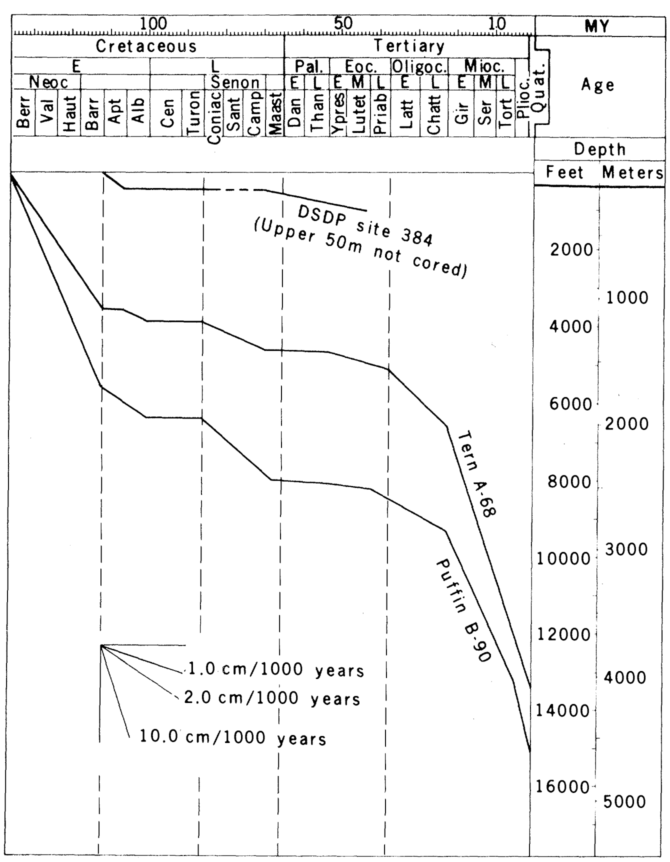
Scoreboard for Reports. We have an uncomfortably large backlog of accepted Reports that await publication. For the past several months we have accepted about 17 Reports per week, a little more than 25 percent of those submitted. In order to reduce the backlog and shorten the publication delay, we will accept only 12 papers per week for the next few months.

the Grand Banks region. In the Puffin B-90 well the Aptian-Albian shales contain carbonate intercalations with orbitolinids. Carbonate rocks with orbitolinids were dredged from the southeast flank of Flemish Cap (Fig. 1), east of the Grand Banks (*12*). The Flemish Cap carbonate was dated as Albian, but a recent study suggests an early Aptian age (*13*). Dredge hauls on one of the Newfoundland seamounts, northeast of the J-anomaly ridge, recovered limestone



Era	Epoch	Age	Puffin B-90 4565.0 m	Tern A-68 4044.0 m	DSDP site 384 330 m
Cenozoic	Late	Mio./Quat.	±428	±1990	Top 50 m not cored
		Miocene	1113.0		
	Early	Oligocene	335.2	±457	
		Eocene L	158.5	±128	
		Eocene M	88.4		±120 m
		Eocene E			
		Paleocene			
Cretaceous	Late	Maast.			±30 m
		Campan.	146.3	±247	
		Santon.-Coniac.	305.0		?
		Turon.-Cenom.			
		Albian	152.4	±101	
	Early	Aptian	91.4		±125 m
		Barrem.	289.6	±1110	
		Neocom.	±1440.0		

Fig. 1 (left). Bathymetry of the Grand Banks region, showing the locations of wells on the Grand Banks and DSDP site 384. The solid line indicates the location of the multichannel seismic profile (*A* to *A'*) drawn in Fig. 5. Fig. 2 (right). Cretaceous and Cenozoic sediment thickness in the Grand Banks wells Puffin B-90 and Tern A-68 and in DSDP site 384, J-anomaly ridge.



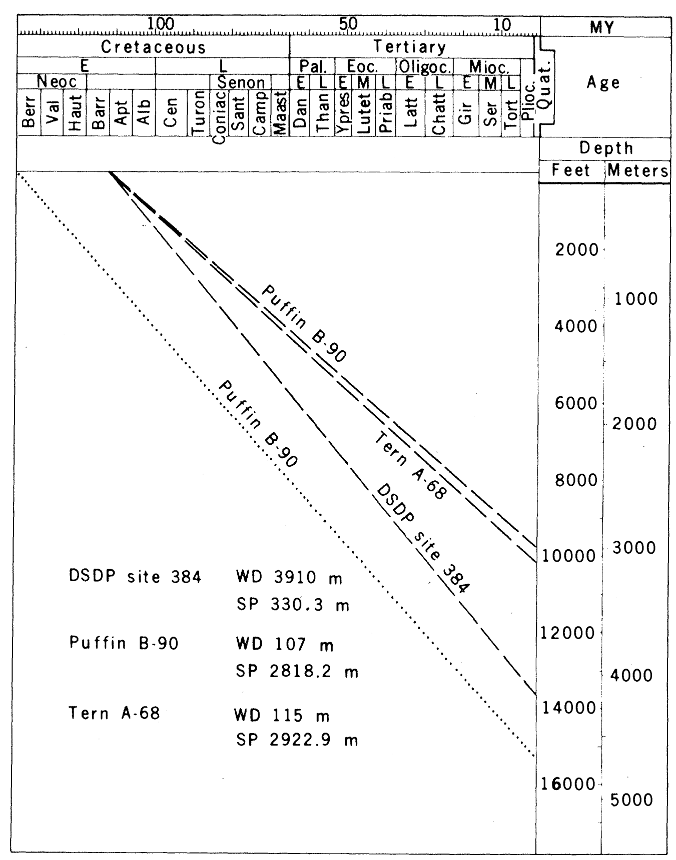


Fig. 3 (left). Sediment accumulation in the Grand Banks wells Puffin B-90 and Tern A-68 and in DSDP site 384, J-anomaly ridge. Fig. 4 (right). Subsidence (depth below present sea level) at the Grand Banks wells Puffin B-90 and Tern A-68 and at DSDP site 384, J-anomaly ridge. Abbreviations: WD, water depth; SP, sediment penetrated younger than Barremian. The dotted line shows total subsidence since the Berriasian in the Puffin well (total depth below sea floor = 4565 m).

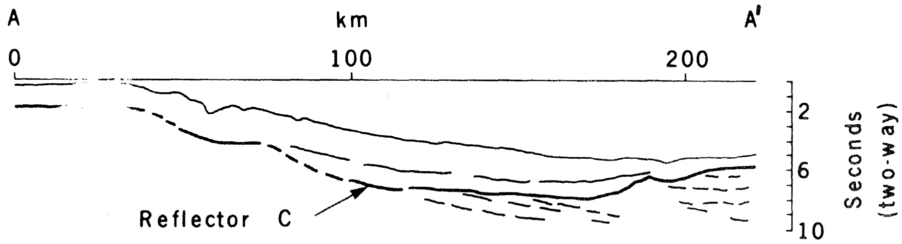


Fig. 5. Line drawing of a multichannel reflection seismic profile extending from the southern Grand Banks to the J-anomaly ridge (see location in Fig. 1).

slabs (*14*) with a poorly preserved microfauna, interpreted by one of us (F.M.G.) as probably Early Cretaceous in age. These carbonates are composed of a mixture of volcanic grains and highly micritized skeletal carbonate grains and are shallow marine in origin. An Albian-Cenomanian coarse, skeletal limestone is present in the Amoco Imp Heron H-73 well (Fig. 1) on the southern Grand Banks margin (*15, 16*).

It would appear that the limestones at site 384 are part of a middle Cretaceous carbonate bank complex which developed along the southern and eastern periphery of the Grand Banks. These carbonate banks were discontinuous and localized in a shallow marine environment in areas of low terrigenous sediment supply near the shelf's margin.

Seismic data provide additional evidence for the relation between the southern Grand Banks margin and the J-anomaly ridge. Figure 5 is a line drawing of a 24-channel seismic reflection profile extending from the southern Grand Banks to the northern flank of the J-anomaly ridge (Fig. 1). A strong reflector, C, can be traced from the Grand Banks, where it has been identified from well control as corresponding to the Early Cretaceous unconformity (*3–5*), to the southern end of the seismic line at a water depth of approximately 3700 m. Sediments overlying reflector C at the southern end of the profile are about 0.6 second thick. Midway along the profile to the north, the sedimentary section over reflector C exceeds 3.0 seconds in thickness. On the southern half of the profile a succession of weak but continuous reflectors expressing apparent southerly dip is visible beneath reflector C. These events are disrupted and show change in attitude beneath the flank of the J-anomaly ridge, but are present to at least 3.0 seconds below reflector C. By extrapolation from the Grand Banks, these events are interpreted as reflections from sedimentary strata, Early Cretaceous or older in age. Assuming that this seismic profile defines the primary nature of the J-anomaly ridge, this feature would appear to be a foundered fragment of the Grand Banks structural block. It is suggested, therefore, that site 384 was drilled to the Early Cretaceous unconformity, where it bottomed probably in a basalt flow rather than in true oceanic basement. This basalt flow might be coeval with mafic extrusions on the Grand Banks and Labrador Shelf (*6, 8*).

The comparable subsidence of the southern Grand Banks margin and the J-anomaly ridge, the presence of coeval shallow marine limestones in both regions, and the presence of seismic reflectors on the flank of the J-anomaly ridge below the strong seismic reflector C lead us to propose as an alternative hypothesis that the J-anomaly ridge was a part of the Grand Banks continental block in (late) Early Cretaceous time. Among the broader implications of this hypothesis is that continental crust extends seaward to the J-anomaly ridge. If the J-anomaly ridge in the eastern Atlantic (*17*) is of similar origin, then less spreading occurred in this segment of the North Atlantic Basin than has generally been proposed (*2*). It would further imply that the southwestern margin of the Grand Banks was probably not the site of a major transform fault during this spreading.

These speculations appear to be in conflict with conventional interpretations of the magnetic anomalies west of the J-anomaly ridge (*2, 18*) and highlight the need for further comparison of the sedimentary and igneous stratigraphy of the southern Grand Banks with that of the adjacent floor of the ocean.

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Chemical Bioinduction of Rubber in Guayule Plant

Abstract. *The treatment of young guayule plants with 2-(3,4-dichlorophenoxy)-triethylamine stimulated the accumulation of polyisoprenoid rubber in the stem and root tissues. This finding suggests that rubber productivity can be improved by the use of chemical agents on guayule and other rubber-forming plants.*

Considerable effort has been directed toward the development of renewable energy sources to alleviate dependence on imported fossil fuel. Attention has focused on the direct production of hydrocarbons in plants such as *Hevea* (*Hevea brasiliensis*, Müll. Arg.), *Euphorbia tirucalli* L., and guayule (*Parthenium argentatum* A. Gray) (*1*). We present evidence for the bioinduction of polyisoprenoid rubber accumulation in guayule by 2-(3,4-dichlorophenoxy)-triethylamine (*2*) and suggest that the finding could make this Compositae shrub of the North American desert a viable domestic source of hydrocarbons, including natural rubber. The amount of rubber accumulated in the stems and roots of treated guayule was marked.

Earlier we reported the chemical bioinduction of tetraterpenoids in a wide range of carotenogenic tissues (*3*). We