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Proto-Oceanic Crust in the North and South Atlantic: types, characteristics, emplacement mechanisms, and its Influence on Deep and Ultra-Deep Water Exploration

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The mechanism of processes that rupture the continental crust, induce crustal extension, begin the initiation of crustal emplacement finally resulting in the drift phase of mid-ocean ridge formation are poorly understood. This is because of our limited knowledge of the deep structure of rifted margins combined with a lack of understanding of the initial "fit" and opening geometries of these margins. As the search for hydrocarbons moves into deep and ultra-deep areas, there is an economic need to better-constrain the architecture of conjugate margins.

Several projects (PROBE, SAMBA, NAMBA) have mapped areas of apparent oceanic crust, which have characteristics that are not those of pure oceanic crust. Neither are they extended continental crust. This crust has been described as "Proto Oceanic Crust" (POC) by Dickson and Odegard (2000), and others.

These projects have integrated seismic, well, gravity, magnetic and topographic data into a Geological Information System (GIS). Results of this integration have shown that the POC has a distinctive gravity and/or magnetic signature. As described by Odegard and Dickson (2001), on seismic sections, POC shows various architectures of seaward dipping reflectors, fragmented crustal segments, and tilted fault blocks with on lapping fill. Depending upon the area POC appears to be either volcanic material, abducted mantle or deep continental crust, separated continental fragments, or a combination of these materials. Emplacement can occur at or near sea level, in regions of restricted lacustrine to oceanic circulation, or open marine environments. The type of material, timing, emplacement mechanism, and depositional environment determines how prospective these areas are for hydrocarbon exploration. This is particularly true in deep and ultra-deep water areas.

Our projects integrated seismic, well, gravity, magnetic, heat flow, sediment thickness and topographic data into a Geological Information System (GIS). In this environment these variables can be correlated easily to delineate trends. We have been able to correlate enhancements (derivatives, dip-azimuth, etc.) of gravity, magnetic and topographic data with manifestations of geological processes. Correlation of these signatures with seismic reflection data and with integrated, modeled profiles has allowed us to calibrate these signatures with real geological processes (Rosendahl, et al., 2002, Weger, et al., 2002, Odegard, et al., 2001). POC is one of these processes.

We also used plate tectonic reconstructions to look at the evolution of the north and south Atlantic regions from initial continental break up to the present by utilizing a program for plate reconstruction of images (grids) and vector interpretations. These are usually done with a series of "snapshots" at various epochs showing their interrelationships (Dickson, et al., 2002; Odegard and Green, 2001). "Movies" can also be constructed at much smaller steps in time to connect each snapshot. This allows us to synthesize and understand the early breakup on the continents when POC was being formed. Because the various enhancements of the data can be reconstructed, along with interpretations, we can see how the various signatures relate to the developmental stages.

Offshore areas of the North and South Atlantic have been examined in this context. These areas include offshore Nova Scotia, Newfoundland, Labrador, Greenland, the Iberian Peninsula, Morocco, East Coast of the United States, Gulf of Guinea, Gabon, Angola and Brazil. Prospectivety in these areas varies widely, but appears to potentially correlate with the type of POC formed in a given area.

Of particular importance is the magnitude of heat flow during and after emplacement. Using a global and local heat flow database from such studies as Pollack, et al. (1991), we have correlated this with crustal types over the North and South Atlantic areas. This has shown the expected relationship of low heat flow with old oceanic crust (~45 to 50 mW/m^2). Extended continental crust has shown a variation from very cold (~25 mW/m^2) to warm (~60 mW/m^2) with a median about 45 mW/m^2. On the other hand, POC, which we might expect to be cooler than extended continental exhibits heat flow over a similar range, but with a median of about 55 mW/m^2. Thus POC would appear to be a relatively good area for hydrocarbon maturation. This must be tempered by considering other variables such as water depth, sediment thickness and burial history. A GIS database, such as the one described above, does, however, allow us to perform "screening" operations on areas of interest using a wide variety of variables.

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