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Results of recent COCORP profiling in the southeastern United States

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Summary. Recently acquired COCORP profiles in the southeastern United States show that: 1) Reflections associated with the Appalachian detachment are prominent beneath the Inner Piedmont of western Georgia, but do not extend further southeast beneath the Pine Mountain belt. 2) The Brunswick magnetic low is associated with a broad zone of crustal-penetrating dipping reflections that probably marks the Alleghanian suture in the southeastern U.S. 3) The South Georgia basin is a composite feature consisting of several half-graben, locally containing >5 km of Triassic - E. Jurassic basin fill. These basins occur within the interior of the Alleghanian orogen, but are not specifically associated with Alleghanian suture. 4) Across-strike crustal thickness variation, and distribution and character of lower-crust and Moho reflections in the Southern Appalachians is grossly similar to that observed in other parts of the Appalachian/Hercynian orogenic belt. Global comparisons suggest that these regional variations are a consequence of post-collisional extensional tectonics, rather than a primary (Palaeozoic or older) feature of the orogenic belt.

1. Introduction

During the winters of 1983-84 and 1984-85 the Consortium for Continental Reflection Profiling (COCORP) collected approximately 1100 km of new deep seismic reflection profile in the southeastern United States. These data, together with previously recorded COCORP profiles in the region, comprise two complete transects of the southern Appalachian orogen extending from the Valley and Ridge province in the northwest to the buried African (Suwannee) terrane underlying northern Florida in the southeast (Fig. 1). The main features of the new western transect have been described in papers by Nelson *et al.* (1985a, b). The older lines comprising the northern portion of the eastern transect (Tennessee line 1, Georgia lines 1, 5, 8) were described by Cook *et al.* (1979, 1981). Here we briefly summarize the main features of COCORP's entire southern Appalachian data set, with emphasis on the new profiles.

2. Appalachian detachment

Reflections associated with the Appalachian detachment are the most prominent feature of the northwestern portions of both the eastern and western COCORP traverses (TN-1, GA-1, GA-23, GA-24, GA-15). On both traverses these reflections comprise a prominent, approximately 0.5 s thick, gently southeast-dipping horizon in the upper crust, which is traceable from the level of the basal detachment within the Valley and Ridge province southeastward for a considerable distance beneath the crystalline interior of the orogen. Well

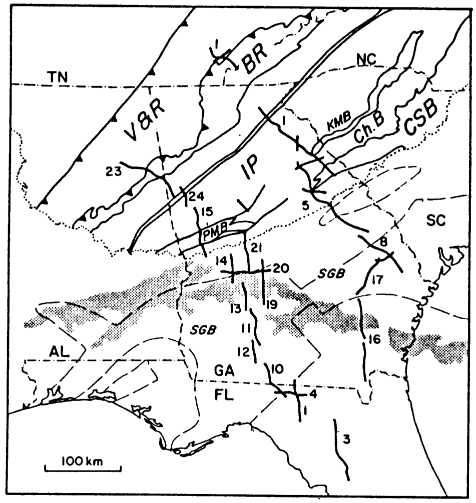

Figure 1. Outline geologic map of the southeastern United States showing location of COCORP lines. V&R - Valley and Ridge province, BR - Blue Ridge, IP - Inner Piedmont, KMB - Kings Mountain belt, Ch. B. - Charlotte belt, CSB - Carolina Slate belt, PMB - Pine Mountain belt, SGB - South Georgia Basin (inside light dashed line), AL - Alabama, GA - Georgia, FL - Florida, NC - North Carolina, SC - South Carolina, TN - Tennessee, heavy dotted line - edge of Cretaceous to Recent Coastal Plain sequence, stipple - Brunswick magnetic low, heavy numbered lines - COCORP lines.

control within the Valley and Ridge province demonstrates that the reflections comprising the northwestern end of this horizon originate from the Cambrian Rome Shale, which carries the basal (Alleghanian) decollement within the foreland. There has been continuing debate as to whether the southeastward continuation of these reflections, beneath the crystalline interior of the orogen, also originate from sedimentary or metasedimentary strata beneath the detachment (i.e. Rome Shale or its southeastward equivalent), or alternatively directly from a mylonite zone. In any case this prominent reflecting horizon is clearly traceable southeastward to the Kings Mountain belt in northeast Georgia (GA-1) where it occurs at about 4 s (about 12 km depth), and to the north flank of the Pine Mountain belt in western Georgia (GA-15) where it occurs at about 3 s (about 9 km depth). These two points are approximately 290 and 220 km respectively across regional strike from the westernmost thrusts cropping out in the Valley and Ridge province. These distances represent the minimum across-strike extent of Alleghanian detachment along the two transects.

On the eastern transect (GA-1), the Appalachian detachment reflections merge eastward, beneath the Kings Mountain belt, into a zone of east-dipping reflections that penetrate deeply into the crust. On the western transect, the distinctive Appalachian detachment reflections do not merge southeastward directly into a zone of dipping reflections. Rather, they terminate abruptly in the subsurface just northwest of the Pine Mountain belt (GA-15, Fig. 2). The Pine Mountain belt is the southernmost interior basement massif within the Appalachians, and has traditionally been thought to consist of several northwest-vergent basement-cored thrust sheets (e.g. Sears & Cook 1984). This view, however, is difficult to reconcile with the observation that reflections associated with the Alleghanian detachment apparently do not continue southeastward *beneath* the belt. This apparent contradiction, together with the observation that the Pine Mountain belt is in fact bounded on the northwest by a northwest dipping mylonite zone, has led us to suggest, alternatively, that the Pine Mountain belt is an asymmetric horst bounded by a post-Alleghanian northwest-dipping normal fault. If

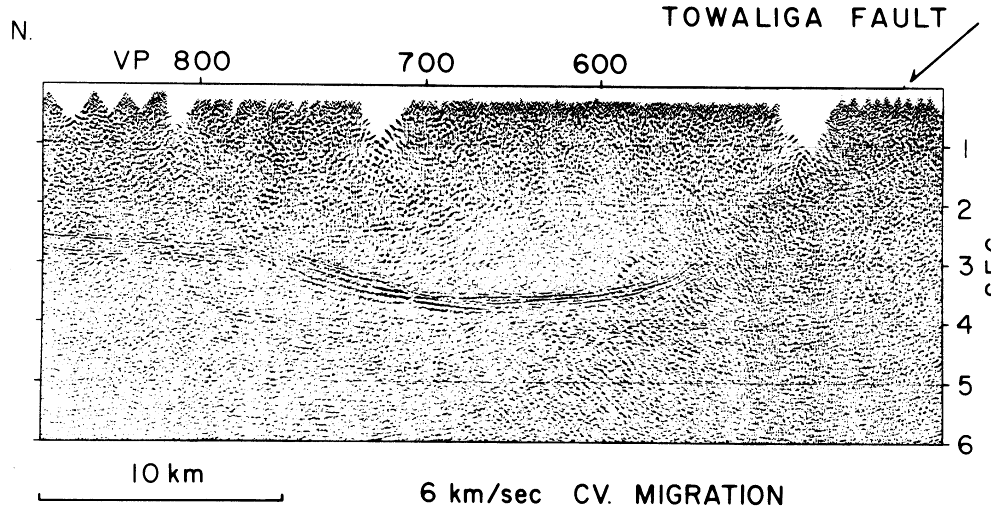

Figure 2. Northern portion of GA-15 showing prominent reflections associated with the Appalachian detachment terminating abruptly against the down-dip projection of the Towaliga fault. This fault forms the northwest boundary of the Pine Mountain belt, the southernmost interior basement massif if the Appalachians. 6 km/s-migrated CDP-stacked section.

correct this interpretation has important implications for extensional tectonics within the Appalachians, and for understanding the nature of the Appalachian detachment, which would in this hypothesis be exposed around the periphery of the Pine Mountain belt.

3. Alleghanian suture

South of the Pine Mountain belt a broad crustal-penetrating zone of dipping reflections and probable diffractions occurs beneath the Coastal Plain in western Georgia (GA-13, 14). This zone is approximately 70 km wide, and grossly wedge-shaped in appearance tapering toward the south (Fig. 3). Most of the reflections defining the zone dip south; however, a number of discrete features with apparent north dip also occur. The zone is bounded at the base by subhorizontal reflections defining a diffuse band between 11 and 12 s (about 33 to 36 km depth), which probably originate from the Moho. Regional relations together with the overall shape and internal geometry of this very distinctive zone suggest that it probably marks the Alleghanian suture between North America and Africa (Gondwana) (Nelson *et al.* 1985a). A notable feature of this reflective zone is its coincidence with the Brunswick magnetic low, which extends eastward across the Coastal Plain of Alabama and Georgia, and the adjacent continental shelf offshore. New lines immediately east of GA-13, 14 (GA-19, 20, 21), and in eastern Georgia (GA-16, 17) confirm that the Brunswick anomaly is associated, regionally, with a distinctive zone of generally south-dipping reflections that extend into the deep crust. In the case of GA-16 this includes one of the highest amplitude mid-crustal reflections ever imaged by COCORP ("Surrency bright spot"). The new data in both eastern and western Georgia further demonstrate that the internal character of the reflective zone varies considerably along strike, and that the reflective zone is not, per se, associated with a Mesozoic rift basin, though locally such basins do coincide with it. These results confirm that the Brunswick anomaly is associated with a major crustal boundary (i.e. suture), and that it is not caused by a Mesozoic rift basin. As we have noted elsewhere, the

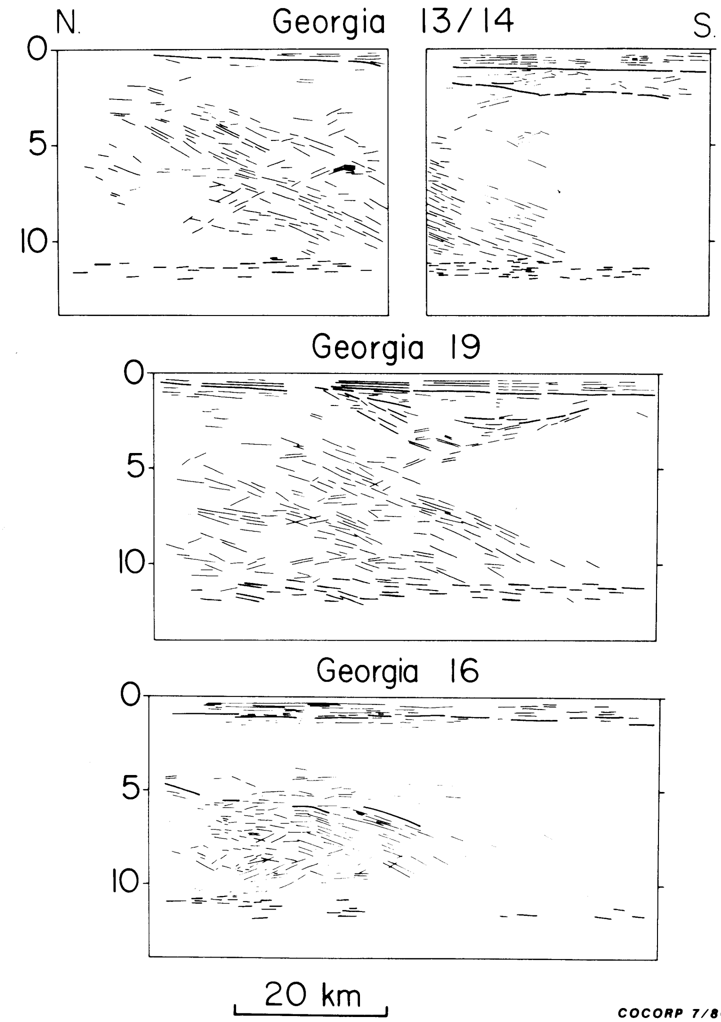

Figure 3. Simplifed line drawings of COCORP profiles crossing the Brunswick magnetic low. The prominent zone of dipping reflections on each profile is thought to mark the Alleghanian suture beneath the southeastern U.S. Subhorizontal reflections above 1 s are from Cretaceous to Recent Coastal Plain sedimentary strata. Subhorizontal reflections below 10 s probably originate from Moho. Line drawings are from unmigrated CDP-stacked sections, 1 to 1 at 6 km s^{-1}.

Brunswick anomaly apparently merges with the East Coast magnetic anomaly offshore, implying that the north-central Atlantic opened on the Alleghanian suture (Nelson *et al.* 1985b).

4. Mesozoic rift basins

The new data in southern Georgia also for the first time elucidate the internal structure of the South Georgia basin (GA-10-14, 17). In terms of areal extent this is the largest on-land Mesozoic basin in eastern North America. The data show that the South Georgia basin is a composite of several large half-graben separated by intervening highs. These basins are tens to >100 km wide and locally contain >5 km of rift basin fill beneath the Cretaceous to Recent Coastal Plain sequence (Fig. 4). Although the border faults to these basins have not been imaged clearly in the basement, the asymmetry of the basins in southwestern Georgia implies that they are bounded by northwest-dipping normal faults. We speculate that these may reactivate southeast-vergent Palaeozoic structures, originally formed on the south side of the Alleghanian suture. Another notable feature of the South Georgia basin is that it appears to be capped, throughout its extent, by an Early Jurassic basalt horizon that postdates the main episode of graben fomation. This basalt is probably corelative with the "J" basalt first recognized in the Charleston, South Carolina region, and traced offshore on U.S.G.S reflection profiles. The implied areal extent of this basalt is greater than 100,000 km^2, ranking it among the great basalt flows of the world.

5. Moho and lower crustal reflections - regional pattern

In general Grenville basement beneath the well-developed Appalachian detachment reflections exhibits few intracrustal reflections, and no obvious reflections from Moho on the COCORP profiles (TN-1, GA-1, 23, 24). Amplitude decay studies, and COCORP profiles elsewhere in the Appalachians suggest that this is a general characteristic of the Grenville basement beneath the Appalachians, rather than a signal penetration problem. Conversely, the crust to the southeast (remaining Georgia and Florida lines) exhibit locally prominent, though intermittent reflections at travel times appropriate for Moho, and at least on the eastern transect, numerous lower crustal reflections (GA-5, 8, 17, 16). A similar transition is observed on COCORP lines across the New England Appalachians (Ando *et al.* 1983). This

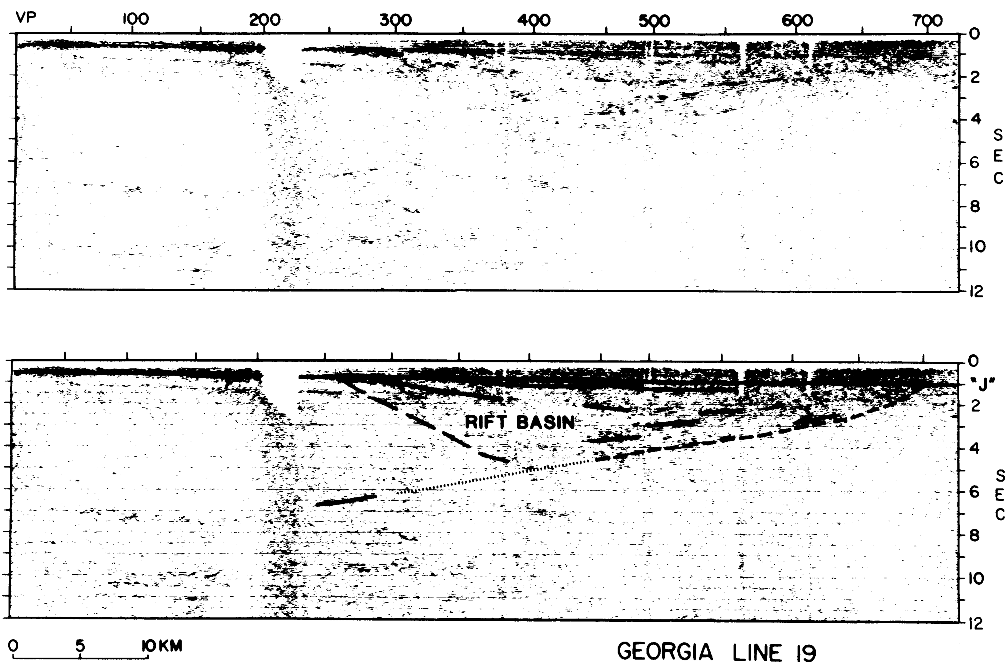

Figure 4. GA-19 showing asymmetric rift basin beneath southeastern U.S. Coastal Plain. This basin is one of several such basins comprising the composite Triassic-Early Jurassic South Georgia basin. J - Early Jurassic basalt horizon. Unmigrated CDP-stacked section, 1 to 1 at 3 km/s.

gross change in reflection character coincides with the zone of eastward crustal thinning in the Appalachians, marked by the Appalachian gravity gradient (Cook 1984). The general view has been that this change in reflection character and crustal thickness marks a primary (Palaeozoic or older) transition from Grenville crust on the west to some other type of crust on the east (Palaeozoic accreted terranes, or Late Precambrian transitional or oceanic crust; e.g. Price & Hatcher 1983; Cook & Oliver 1981). Recent reflection results elsewhere, however, suggest that this transition may equally well be a consequence of Mesozoic extension and/or related igneous activity affecting the region east of the Appalachian gravity gradient. In particular, COCORP profiles across the Basin and Range/Colorado Plateau transition zone and foreland-hinterland transition of the NW Cordillera (Potter *et al.*, this issue), and an ECORS profile across the Hercynian foreland-hinterland transition in France (Bois *et al.* 1986) all show grossly similar transitions to the one observed in the Appalachians. In all of these regions, including the Appalachians, the areas underlain by thinner more reflective crust, and reflective Moho were subjected to post-collisional extensional tectonics. There is thus a fundamental ambiguity in interpreting the gross change in reflection character and crustal thickness in the Appalachians. Is this transition a primary consequence of Palaeozoic collisional tectonics, or Mesozoic rifting, or both? Answering this question is fundamental to understanding the evolution of the orogenic belt.

Acknowledgements

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