Title of article: Block-Tilting, Transfer Faults, and Structural Control of Magmatic and Hydrothermal Processes in the TAG Area, Mid-Atlantic Ridge 26°N

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Supplementary Observational Data from ALVIN Dives in the TAG Area, 26°N Mid-Atlantic Ridge

The following brief dive summaries emphasize key structural observations made on the walls of the Mid-Atlantic Ridge (MAR) during an ALVIN diving program in 1982. The dive numbers are 1240-1247; 1241 was aborted before reaching the bottom. These data are included here in support of interpretations presented in "Block-Tilting, Transfer Faults, and Structural Control of Magmatic and Hydrothermal Processes in the TAG Area, Mid-Atlantic Ridge 26°N" by J.A. Karson and P.A. Rona, 1990, Geological Society of America Bulletin, v. , p..

Results of ALVIN dives. In this section we briefly describe each of the 1982 ALVIN dives with special emphasis on faults and related structures. More information regarding hydrothermal activity in this region may be found in Rona et al. (1984). See Figure 4 for dive locations and Figure 5a for a general summary.

DIVE 1240 -- The first dive in this series began at a depth of 3120 m and ascended the eastern median valley wall along an EW course up to
a depth of 2720 m (Figs. 6 and 7). The first half of the dive transversed broad, open slopes underlain by downslope lineated debris slide deposits incipiently buried by bioturbated, locally rippled, calcareous ooze. About midway through the dive, (depth 2975 m) a steeper interval (about 30°) is covered with downslope-lineated debris slides with very little sediment cover. Very large blocks or small pillow lava outcrops emerge from the rubble locally. This is interpreted as an area of very recent mass wasting, and perhaps a highly degraded fault line scarp. CTFM Sonar showed that this area produced a linear reflector at least 500 m in length trending 340°. The second half of the dive crossed old sediment-covered slopes scarred by isolated debris slides.

At the end of the dive (2720 m depth) the crest of a linear (NS) ridge was reached. This is clearly a fault-line scarp. The uppermost 10 m is a near-vertical free face trending 340° exposing truncated pillow basalts capped by about 1.5 m of medium bedded chalced. Smooth carbonate sediment blankets the slope for at least a few tens of meters to the east on a slope that is less steeply inclined than the dip of the bedding in the underlying chalced. Bedding in the chalced dips approximately 35° to the ENE (≈050°). Just east of the lip of the scarp broken slabs of chalk and ferro-manganese crusts litter the 25-30° east-facing slope.

DIVE 1242 -- This dive proceeded uphill from west to east several kilometers to the south of the previous dive (Dive 1241 was aborted -- Figs. 6 and 7). It began at 3100 m and ended at 2600 m water depth. Most of the dive crossed monotonous carbonate ooze interrupted only by small outcrops of ferromanganese crusts, or
basalts. Locally, large blocks of pillow basalt or basaltic breccia occur. Black hydrothermal stains (Rona et al., 1984) appear intermittently. A minor fault-line scarp trending 062° and facing southeast exposes fractured basalts over a fresh talus ramp at 2650 m depth. The easternmost part of the dive traversed a NS scarp covered with lineated debris slides and minor sediment cover. At the base of this scarp, a small scarp (<50 m high) slopes about 70° to the east. The final segment of the dive ascended a major fault scarp (2480 m to 2350 m depth) that steepened progressively from about 40° at the base to at least 70° at the headwall. Fractured and truncated pillow basalts crop-out continuously across this area. The free face at the crest of this scarp trends 025° and is capped by disrupted slabs of chalk and ferromanganese deposits that have been dislodged from bedded lithologies atop the lava sequence. The slope falls away rapidly (about 30°) to the ESE, essentially a dip-slope parallel to the chalk bedding.

DIVE 1243 -- This dive traversed the interval between depths of 3000 m and 2400 m from west to east (Figs. 6 and 7). The first 800 m crossed pelagic ooze with protruding ridges of rubble or large boulders of pillow lava. Minor hydrothermal stains were noted. At a depth of 2950 m, a large mound of low-temperature hydrothermal material was found (Rona et al., 1984). After a relatively steep (~30°) interval of lineated debris slides, a 400-500 m wide section of pillow lavas was crossed. This outcrop area is crossed by several debris slides and is littered with loose talus. The upper half of the outcrop is cut by several NS fault-line scarps, all facing west. A few trap-door structures produced by intersecting NS and EW faults
were observed. At the top of this outcrop area a minor (10-20 m high) EW scarp drops off steeply to the south. On this face at least three diabase dikes were observed cutting the lavas. Their strike could not be accurately determined but appeared to be nearly NS. They dip westward at 70°.

The next leg of the dive was a N to S transect about 500 m long. The first half crossed pelagic ooze and minor rubble. The second half traversed a steep NS slope obliquely crossing fresh debris slides and minor pillow basalt outcrops.

The next 250 m moved directly up a major fault scarp to the east. The lower part of the fault was marked by slickensided basaltic surfaces dipping WNW with slickenside lineations plunging downdip at 40-50°. Rubble and debris slides hide the fault surface in many places. Upslope minor 295° fractures cut the fault surface and erosional gullies and mass wasting scars produce a very uneven surface. The headwall of the scarp trends 355° and dips about 70° west. Pillow basalts here are capped by 1-2 m of bedded chalks dipping at least 30° to the east. The dip-slope falls away rapidly to the east and pelagic ooze covers the surface.

After almost 200 m out of contact with the bottom, another major fault scarp was crossed. It is at least 300 m wide and 160 m high. The lowest outcrops are massive basaltic rock with well developed slickensided surfaces dipping 30-40° westward. Downdip plunging grooves and striae parallel the slickensides. Minor faults trending 350° and 090° disrupt this surface. Midway up this scarp a number of EW fault-line scarps cut the 45°-dipping fault surface. Outcrops along these EW walls showed several NE-trending dikes all
very irregular but approximately vertical. Moving N across this scarp, slickensided surfaces are cut by much steeper faults trending 355° to 010°. Rugged outcrops of pillow lava, rubble and minor ooze to the E give way to yet another NS fault scarp. This one is only 120 m high and has well-developed slickensided fault surfaces dipping 50° to the W. Pillow basalts at the crest of the fault scarp are capped by an 0.5 m thick chalk bed that dips 40° to the E. The final segment of the dive crossed about 250 m of basaltic rubble, debris slides and minor pockets of sediment.

DIVE 1244 -- This dive zig-zagged upslope from 3000 m to 2500 m depth in a series of NS traverses. Nearly all of the area covered was blanketed by pelagic ooze with intermittent hydrothermal stains. A few widely spaced debris slides and basaltic outcrops were seen, but no significant fault scarps were crossed.

DIVE 1245 -- Beginning at a depth of 2600 m and ending only about 1.2 km upslope at 2320 m, this dive crossed a major fault zone. The first 300 m of the dive ascended an extensive, active talus ramp with numerous individual debris slides. Basaltic clasts dominate but a few large blocks of basaltic breccia up to 1.5 m across and a few blocks of chalky sedimentary rock were also found. Slickensided surfaces dipping about 60° to the west emerge from the talus at a depth of 2560 m. The fault surface is somewhat steeper than some of the others seen in the area and is gently undulating. It is interrupted by a number of late faults trending NS (up to 10 m high) and EW (10-20 m high). These fault scarps provide a cross section of structures in the footwall of the master fault. In some areas, usually within 1-2 m of the fault surface, very platey material that
appears to have a penetrative foliation parallel to the fault was observed. The EW scarps locally showed very gently west-plunging slickensides suggesting oblique-slip displacement. Pillow lavas exposed in the scarps are cut by massive, jointed dikes that locally make up 20-30% of the outcrop. The dikes strike 010° to 020° and dip 70° to the west.

Just above the crest of the scarp, rugged pillow lava outcrops with about 20 cm of sediment slope steeply up to the east. The fault surface has probably been removed from this area by mass wasting. The top of the slope is once again marked by outcrops of bedded chalk up to 0.5 m thick that directly overlie pillow lavas. These are well exposed in a 6 m-high, NS, vertical scarp. The dip of the chalk beds was not accurately determined here, but the east-facing slope just behind the fault zone, probably a dip-slope, is inclined at 15-20°. Smooth, undisturbed calcareous ooze covers the seafloor for the final 200 m of the dive.

DIVE 1246 -- This dive investigated a major EW wall in the overall NS-trending median valley wall. It consisted of three legs: an oblique ascent of a NS fault zone followed by an east to west transect of the EW-trending wall and finally a short climb to the south and east into a complexly faulted area.

The first leg of the dive first climbed a major inactive slope (2570 m-2500 m depth) underlain by old, sedimented debris slide deposits. These passed upslope into active basalt and basaltic breccia clast debris slides and continuous talus. The next 350 meters consisted of a very rugged pillow lava terrane, probably a fault-line scarp trending 020°, that has an overall serrated form
due to intersecting NS- and WNW-trending fault-line scarps. These scarps are very linear and range from a few meters to a few tens of meters in height. Loose rubble, including blocks up to a few meters across are strewn across the less steeply inclined surfaces. WNW- to EW-trending walls become more closely spaced to the south and two vertical EW fault zones occur near the top of this wall. These shear zones are about 1-2 m wide, have very little relief and are characterized by a crudely developed phaccoidal fabric defined by anastomosing fractures bounding (apparently) undeformed blocks of basalt. We interpret these as strike-slip fault zones.

The crest of the fault zone was reached at 2480 m depth. Just below a small (2 m high) vertical scarp at this ridge crest slickenside fault surfaces dipping 20-30° to NNW crop out locally. Crudely bedded chalks cap the lavas and are back-tilted (east-dipping) about 40°. Detached slabs of chalk have apparently slid down the steep east-facing slope just to the east.

Continuing to the south, the dive climbed directly up a 40° to 50° slope facing to the north, the edge of the EW ridge. This slope is underlain by massive to crudely bedded breccias that dip 40° to the north (000°). The breccias are composed of variably weathered basaltic clasts (pebble to cobble size) in a matrix of well indurated carbonate mud and minor ferromanganese clasts reaching sand size. These deposits are deeply scarred by erosional gullies and slumps that create uplift of several meters on the slope face. We believe this is either a reactivated old talus ramp in which mass wasting processes have mixed rubble and accumulated sediment, or perhaps a region with a protracted history of mass wasting that has
been active long enough for substantial sediment to have accumulated and mixed with the basaltic rubble.

At the top of this slope (2370 m) two minor EW-trending, north-facing scarps (2-5 m high) were crossed just before entering a region of highly fractured pillow lavas and rubble. Both north- and south-facing EW scarps were crossed as a loop was traversed along another major NNE-trending wall. This wall is dominated by fresh basaltic talus and lineated debris slides.

The second leg of the dive progressed east to west along the northern tip of the major EW-trending ridge. To the west we crossed a monotonous undulating slope (facing north) covered with pillow basalt talus. Locally scoop-shaped slump scars cut into this material.

Turning again to the south on the final leg (2530 m-2360 m), a series of EW- to WNW-trending vertical scarps were crossed. Locally these gave the impression of a horst and graben terrane. Just to the south a near-vertical wall of truncated pillow basalts trending mainly 035° with dog-legs trending 350° shows vertical fractures cutting west-dipping (45° to 50°) slickensided surfaces and platy, foliated intervals. Upslope to the east more massive to tabular lithologies with slabs of material dipping 45° to the west are truncated on a series of west-facing vertical rock walls. Samples collected here show this material to be well indurated fault breccias composed of highly fractured and altered (basaltic?) clasts in a matrix of finely crushed rock fragments and carbonate. The crest of this slope was reached at 2360 m depth and was marked by highly fractured basalts cut by minor scarps trending both NS and
EW. A few large (0.5 m) blocks of chalky sediment are present but no coherent bedded unit was formed.

DIVE 1247 -- This dive provided little information concerning bedrock or fault structures. It followed a complex zig-zag course upslope from 2950 m to 2550 m depth in a general west to east direction. Nearly the entire dive was over pelagic ooze with local cobbles or blocks of basaltic material and a few mounds of fresh, low-temperature hydrothermal deposits consisting of manjanese oxides and iron silicates (Rona et al., 1984; Thompson et al., 1985). Basaltic rubble in the form of downslope-lineated debris slides occurs on the steeper slopes.