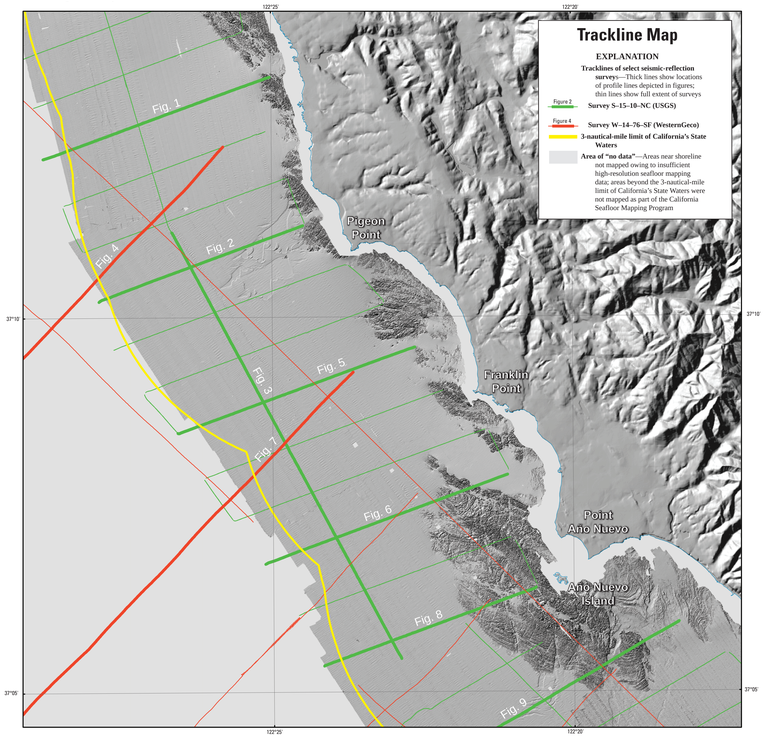
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1232
Sheet 8 of 10
Pamphlet accompanies map



Onshore elevation data from California Coastal Conservancy (available from National Oceanic and Atmospheric Administration [NOAA] Coastal Service Center's Digital Coast at http://www.csc.noaa.gov/digitalcoast/inventories/lidar) and from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). California's State Waters limit from NOAA Office of Coast Survey.
Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:50 000

2 1 0 2 MILES
7000 3500 0 7000 FEET
1 0.5 0 1 KILOMETER
ONE MILE = 0.869 NAUTICAL MILES

GIS database and digital cartography by Janet T. Watt, Stephen R. Hartwell, and Peter Dartnell
Manuscript approved for publication December 4, 2015

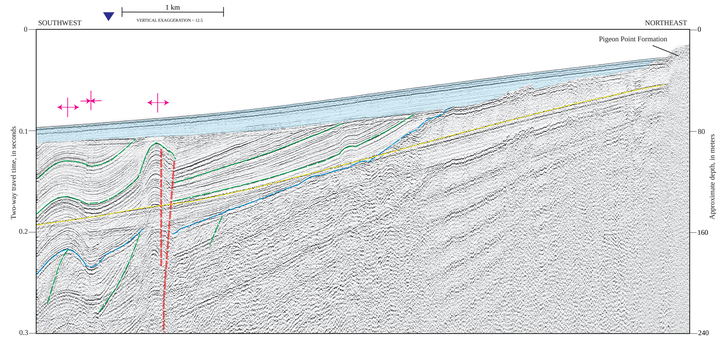


Figure 1. USGS high-resolution minisparker seismic-reflection profile P10–35 (collected in 2010 on survey S–15–10–NC), which crosses shelf northwest of Pigeon Point; see trackline map for location. Profile highlights faulted and folded strata along the northeast margin of the Outer Santa Cruz Basin (see fig. 10 for location). Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Tertiary and Cretaceous strata. Dashed blue lines show unconformities. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

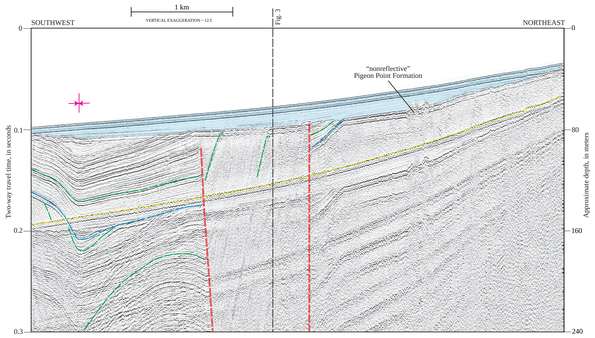


Figure 2. USGS high-resolution minisparker seismic-reflection profile P10–35 (collected in 2010 on survey S–15–10–NC), which cross shelf west of Pigeon Point; see trackline map for location. Profile highlights faulted and folded strata along the northeast margin of the Outer Santa Cruz Basin (see fig. 10 for location). Dashed red lines show faults. Magenta symbol shows fold axis (converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Tertiary and Cretaceous strata. Dashed blue lines show unconformities. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

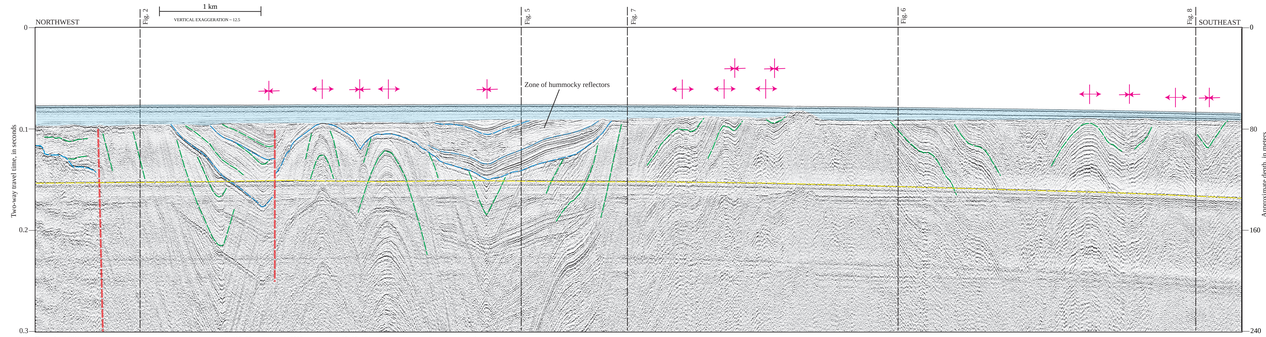


Figure 3. USGS high-resolution minisparker seismic-reflection profile P10–39 (collected in 2010 on survey S–15–10–NC), which crosses shelf southwest of Pigeon Point; see trackline map for location. Profile highlights faulted and folded strata beneath continental shelf. Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image variably deformed Tertiary and Cretaceous strata. Dashed blue lines show unconformities. Note zone of hummocky reflectors between otherwise parallel to subparallel reflectors (see cross-line, fig. 5). Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

DISCUSSION

This map sheet shows seismic-reflection profiles from three different surveys of the Offshore of Pigeon Point map area, providing imagery of the subsurface geology. This map area is characterized by a relatively flat (less than 1°) inner and midshelf, extending to water depths of about 70 m at the limit of California's State Waters. Most of the shelf north of Point Año Nuevo is covered by unconsolidated sandy and muddy sediment. Bedrock forms moderate-relief outcrops that locally extend from the shoreline to water depths of about 30 m, except offshore of Point Año Nuevo, where bedrock is exposed at the seafloor to water depths of greater than 40 m (sheets 1, 2, and 10). The seismic-reflection profiles provide the data for interpreting subbottom stratigraphy, sediment thickness, and geologic structure (see sheets 5, 10).

Most profiles displayed on this sheet (figs. 1, 2, 3, 5, 6, 8, 9) were collected in 2009 and 2010 on U.S. Geological Survey (USGS) cruises S–N1–09–MB and S–15–10–NC, respectively. The single-channel seismic-reflection data were acquired using a SIG 2Mille minisparker that used a 500-J high-voltage electrical discharge fired 2 times per second, which, at normal survey speeds of 4 to 4.5 nautical miles per hour, gives a data trace every 1.0 to 1.5 m of lateral distance covered. The data were digitally recorded in standard SEG-Y 32-bit floating-point format, using Triton Subbottom Logger (SBL) software that merges seismic-reflection data with differential GPS-navigation data. After the survey, a short-window (20 ms) automatic gain control algorithm was applied to the data, along with a 160- to 1,200-Hz bandpass filter and a heave correction that uses an automatic seafloor-detection window (averaged over 30 m of lateral distance covered). These data can resolve geologic features a few meters thick (hence, are considered "high-resolution"), down to subbottom depths of as much as 400 m.

Figures 4 and 7 show migrated, deep-penetration, multichannel seismic-reflection profiles collected in 1976 by WesternGeco on cruise W–14–76–SF. These profiles and other similar data were collected in many areas offshore of California in the 1970s and 1980s when these areas were considered a frontier for oil and gas exploration. Much of these data have been publicly released and are now archived at the USGS National Archive of Marine Seismic Surveys (U.S. Geological Survey, 2009). These data were acquired using a large-volume air-gun source that has a frequency range of 3 to 40 Hz and recorded with a multichannel hydrophone streamer about 2 km long. Shot spacing was about 30 m. These data can resolve geologic features that are 20 to 30 m thick, down to subbottom depths of about 4 km.

Faults in the offshore part of the Offshore of Pigeon Point map area are identified in seismic-reflection profiles based on abrupt truncation or warping of reflections and (or) the juxtaposition of reflection panels with different seismic parameters, such as reflection presence, amplitude, frequency, geometry, continuity, and vertical sequence. The map area encompasses a part of the continental shelf that lies between the Ascension Fault and the San Gregorio Fault Zone, along the northeastern margin of the Outer Santa Cruz Basin and the southwest limb of the Pigeon Point high (McCulloch, 1987) (fig. 10). This map area is characterized by a number of steeply dipping, predominantly northwest-striking, unnamed faults. These faults show a vertical separation of reflections and commonly juxtapose different reflection panels, suggesting a combination of reverse and strike-slip faulting. This faulting is associated with a complex pattern of folding, particularly within the Monterey Formation offshore Point Año Nuevo (see figs. 6, 8; see also, sheet 10). Rates of Pleistocene-age vertical uplift onshore, west of the San Gregorio Fault Zone, range from 0.31 to 0.35 m/ka (Clark and others, 1999), and cumulative lateral slip on the San Gregorio Fault Zone is thought to range from 4 to 10 mm/yr in this area (Weber and others, 1995).

On high-resolution seismic-reflection profiles, the Upper Cretaceous Pigeon Point Formation is essentially nonreflective (figs. 1, 2, and 5). The overlying Tertiary strata are moderately to highly deformed, and are generally characterized by continuous, parallel to subparallel, variable amplitude, high-frequency reflections (terminology after Mitchum and others, 1977). Onshore west of the San Gregorio Fault Zone, the Tertiary section includes Oligocene and Miocene unnamed sedimentary and volcanic rocks, the middle and upper Miocene Monterey Formation, and the upper Miocene and Pliocene Purissima Formation (Powell and others, 2007; Brabb and others, 1998; Clark and others, 1999). Whereas the Santa Cruz Mudstone is absent in the onshore sections, it is present in offshore wells within the Outer Santa Cruz Basin (Heck and others, 1990), and may also be present in the subsurface within the offshore part of the Offshore of Pigeon Point map area.

Throughout the map area, the contact between Tertiary bedrock and overlying upper Quaternary sediments is an angular unconformity. These unconsolidated sediments were deposited in the last about 21,000 years during the sea-level rise following the Last Glacial Maximum (LGM; Lambeck and Chappell, 2001; Peltier and Fairbanks, 2006). Sea level was about 125 m lower during the LGM, at which time the Offshore of Pigeon Point map area was emergent. The post-LGM sea-level rise was rapid (about 9 to 11 m per thousand years) until about 7,000 years ago, when it slowed considerably to about 1 m per thousand years (Peltier and Fairbanks, 2006; Stanford and others, 2011). Sediments deposited during the post-LGM sea-level rise (the rapid transgression and post-about 7 ka highstand) are shaded blue in the high-resolution seismic-reflection profiles (figs. 1, 2, 3, 5, 6, 8, and 9); the combined thickness of this unit, and another upper Quaternary unit not present in this map area, are shown on sheet 9 (Maps B, D).

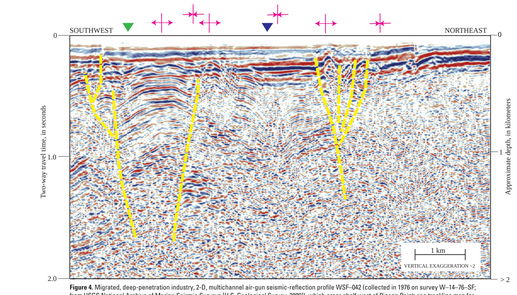


Figure 4. Migrated, deep-penetration industry, 2-D, multichannel air-gun seismic-reflection profile WSF-042 (collected in 1976 on survey W–14–76–SF; from USGS National Archive of Marine Seismic Surveys (U.S. Geological Survey, 2009)), which cross shelf west of Pigeon Point; see trackline map for location. Note that vertical scale and exaggeration are significantly different than that of high-resolution profiles shown in figures 1, 2, 3, 5, 6, 8, and 9. Dashed yellow lines show a number of unnamed faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Purple triangle shows location of California's State Waters limit (yellow line on trackline map). Green triangle shows location of map boundary.

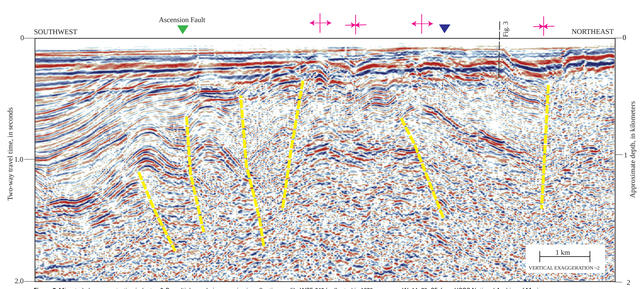


Figure 7. Migrated, deep-penetration industry, 2-D, multichannel air-gun seismic-reflection profile WSF-040 (collected in 1976 on survey W–14–76–SF; from USGS National Archive of Marine Seismic Surveys (U.S. Geological Survey, 2009)), which crosses shelf west of Point Año Nuevo; see trackline map for location. Note that vertical scale and exaggeration are significantly different than that of high-resolution profiles shown in figures 1, 2, 3, 5, 6, 8, and 9. Profile highlights multiple faults (dashed yellow lines) beneath the continental shelf, including the Ascension Fault located southwest of map area (see fig. 10 for location). Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Purple triangle shows location of California's State Waters limit (yellow line on trackline map). Green triangle shows location of map boundary.

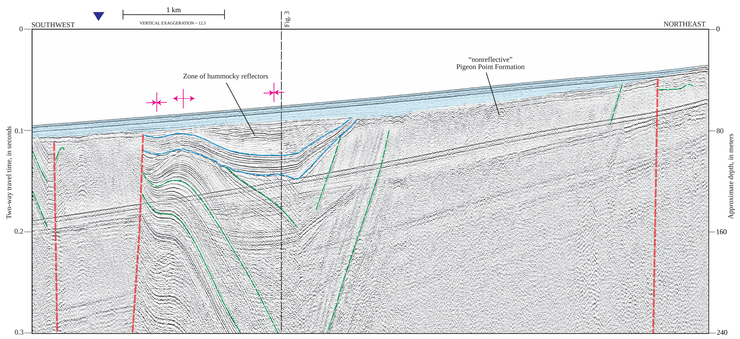


Figure 5. USGS high-resolution minisparker seismic-reflection profile P10–25 (collected in 2010 on surveys S–15–10–NC), which crosses shelf south of Pigeon Point; see trackline map for location. Profile highlights faulted and folded strata beneath continental shelf. Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Tertiary and Cretaceous strata. Dashed blue lines show unconformities. Note zone of hummocky reflectors between otherwise parallel to subparallel reflectors near middle of profile (see cross-line, fig. 3). Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

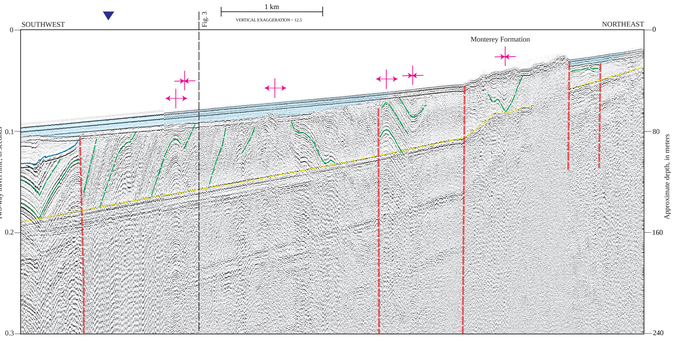


Figure 6. USGS high-resolution minisparker seismic-reflection profile P10–20 (collected in 2010 on survey S–15–10–NC), which crosses shelf northwest of Año Nuevo Island; see trackline map for location. Profile highlights faulted and folded strata beneath continental shelf. Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Tertiary strata, including the Monterey Formation, which is exposed on the seafloor. Dashed blue line shows unconformity. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

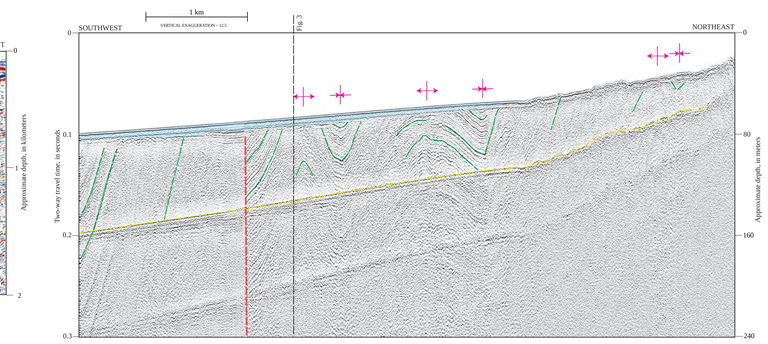


Figure 8. USGS high-resolution minisparker seismic-reflection profile P10–38 (collected in 2010 on survey S–15–10–NC), which crosses shelf northwest of Año Nuevo Island; see trackline map for location. Profile highlights faulted and folded strata beneath continental shelf. Dashed red line shows fault. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Tertiary strata. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

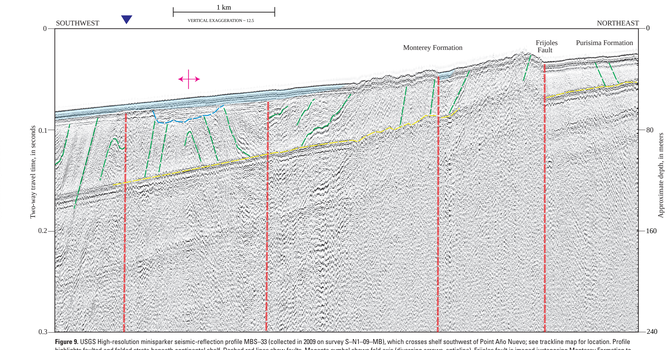


Figure 9. USGS High-resolution minisparker seismic-reflection profile MBS–33 (collected in 2009 on survey S–N1–09–MB), which crosses shelf southwest of Point Año Nuevo; see trackline map for location. Profile highlights faulted and folded strata beneath continental shelf. Dashed red lines show faults. Magenta symbol shows fold axis (diverging arrows, anticline). Frijoles fault is imaged juxtaposing Monterey Formation to southwest with Purisima Formation to northeast. Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Tertiary strata. Dashed blue line shows unconformity. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

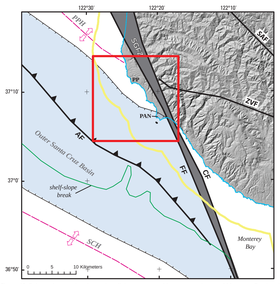


Figure 10. Schematic map showing major offshore structural features northwest of Monterey Bay (modified from Nagel and others, 1986; McCulloch, 1987; Wagner and others, 2002; Dickinson, 2005). Red box, Offshore of Pigeon Point map area. Yellow line, offshore limit of California's State Waters. Outer Santa Cruz Basin (modified from McCulloch, 1987) shown by blue shading and hachured lines (hachures point into basin). Solid black lines show traces of faults: AF, Ascension Fault (sawteeth on upper plate); CF, Coastways Fault; FF, Frijoles Fault; SGFZ, San Gregorio Fault Zone (also shown by dark-gray shading); SAF, San Andreas Fault; ZYF, Zayante-Vergeles Fault. Dashed magenta lines show axes of structural highs: PPH, Pigeon Point high; SCH, Santa Cruz high. Other abbreviations: PAN, Point Año Nuevo; PP, Pigeon Point.

Seismic-Reflection Profiles, Offshore of Pigeon Point Map Area, California

By
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2015

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Supplemental Publication: Nagel, D.K., Mullins, H.T., and Greene, H.G., 1986, Ascension submarine canyon, California—Evolution of a multi-head canyon system along a strike-slip continental margin: Marine Geology, v. 73, p. 295–310.

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