32, no. 5, p. A-12.

Geological Society of America Abstracts with Programs, v

Geometry, mechanisms and significance of extensional folds

from examples in the Rocky Mountain Basin and Range prov-

ince, U.S.A.: Journal of Structural Geology, v. 20, no. 7, p.

M'Gonigle, J.W., 2000c, Long-distance longitudinal transport

of gravel across the Cordilleran thrust belt of Montana and

Janecke, S.U., VanDenburg, C.J., Blankenau, J.J., and

Kiilsgaard, T.H., Fisher, F.S., and Bennett, E.H., 1986, The

Trans-Challis fault system and associated precious metal de

posits, Idaho: Economic Geology, v. 81, no. 3, p. 721–724.

Mountain area Montana-Idaho: University Park, Pa., Pennsyl-

W.J., Jr., Sears, J.W., Bartholomew, M.J., Stickney, M.C.

Fritz, W.J., Hurlow, H.A., and Thomas, R.C., 2000, Prelimi

nary geologic map of the Lima 30' x 60' quadrangle, south-

File Report MBMG 408, scale 1:100,000, includes pam-

Beaverhead County, Montana: U.S. Geological Survey Mis-

cellaneous Geologic Investigations Map I-433, scale

Montana: University Park, Pa., Pennsylvania State University

Snowcrest Range—A Rocky Mountain foreland uplift in

tonics on fold-thrust belt geometry, southwestern Montana:

Lexington, Ky., University of Kentucky Ph.D. dissertation,

Peak quadrangle, Beaverhead County, southwest Montana:

U.S. Geological Survey Geologic Quadrangle Map GQ-1724

Pardee, J.T., 1950, Late Cenozoic block faulting in western Mon-

• Perry, W.J., Jr., Haley, J.C., Nichols, D.J., Hammons, P.M., and

tana: Geological Society of America Bulletin, v. 61, no. 4, p.

Ponton, J.D., 1988, Interactions of Rocky Mountain foreland

and Cordilleran thrust belt in Lima region, southwest Monta-

na, in Schmidt, C.J., and Perry, W.J., Jr., eds., Interaction of

the Rocky Mountain foreland and the Cordilleran thrust belt:

Geological Society of America Memoir 171, p. 267–290.

stone hot spot—Volcanism, faulting, and uplift, in Link, P.K.

Kuntz, M.A., and Platt, L.B., eds., Regional geology of east

ern Idaho and western Wyoming: Geological Society of

faulting, western Montana and east-central Idaho, in New-

man, G.W., and Goode, H.D., eds., Basin and Range Sympo

sium and Great Basin Field Conference: Denver, Colo., Rocky

Montana thrust belt, in Link, P.K., Kuntz, M.A., and Platt

L.B., eds., Regional geology of eastern Idaho and western

Wyoming: Geological Society of America Memoir 179, p.

Royse, F., Jr., Warner, M.A., and Reese, D.L., 1975, Thrust belt

structural geometry and related stratigraphic problems,

drilling frontiers of the central Rocky Mountains: Denver, Co

lo., Rocky Mountain Association of Geologists, p. 41–54.

Ruppel, E.T., 1968, Geologic map of the Leadore quadrangle

● ——1993, Preliminary geologic map of the Tepee Mountain

Ryder, R.T., and Scholten, Robert, 1973, Syntectonic conglomer

Oregon State University, M.S. thesis, 294 p.

Programs, v. 16, no. 4, p. 253.

4, p. 345–404, scale 1:130,000.

75, no. 4, p. 1053–1066.

84. p. 773–796

Quadrangle Map GQ-733, scale 1:62,500.

Wyoming-Idaho-northern Utah, in Bolyard, D.W., ed., Deep

Lemhi County, Idaho: U.S. Geological Survey Geologic

-1978, Medicine Lodge thrust system, east-central Idaho and

southwestern Montana: U.S. Geological Survey Professional

quadrangle, Montana: Montana Bureau of Mines and Geology

Open-File Report 317, scale 1:24,000, includes 8-page pam-

ates in southwestern Montana—Their nature, origin, and tec-

tonic significance: Geological Society of America Bulletin, v.

Creek area, Beaverhead County, Montana: Corvallis, Oreg.

range-boundary normal faults by earlier structures, southwest-

ern Montana: Geological Society of America Abstracts with

ology of the Lima region, southwestern Montana and adja-

cent Idaho: Geological Society of America Bulletin, v. 66, no.

nisms indicated by structural framework of central Beaverhead

Mountains, Idaho-Montana: Geological Society of America

tectonic setting of the 1983 Borah Peak earthquake, central

na—Implications for the initial outbreak of the Yellowstone

hotspot, in Thomas, R.C., ed., Geologic history of the Dillon

area, southwestern Montana: Northwest Geology, v. 25, p.

western Montana—Interference among three generations of

extensional fault systems, in Faulds, J.E., and Stewart, J.H.,

eds., Accommodation zones and transfer zones—The region-

al segmentation of the Basin and Range province: Geological

Sears, J.W., and Fritz, W.J., 1998, Cenozoic tilt domains in south

Society of America Special Paper 323, p. 241–247.

Sears, J.W., Hurlow, Hugh, Fritz, W.J., and Thomas, R.C., 1995,

Late Cenozoic disruption of Miocene grabens on the shoulder

of the Yellowstone hotspot track in southwest Montana—Field

guide from Lima to Alder, Montana, in Mogk, D.W., ed.,

Field guide to geologic excursions in southwest Montana,

Rocky Mountain section, GSA Annual Meeting, Bozeman,

Mont., May 16-21, 1995: Northwest Geology, v. 24, p.

Peak and Italian Peak Middle Roadless Areas, Beaverhead

County, Montana, and Clark and Lemhi Counties, Idaho:

U.S. Geological Survey Miscellaneous Field Studies Map

—1985, Contraction and extension faults in the southern Bea

verhead Mountains, Idaho and Montana: U.S. Geological Sur

verhead Mountains, Idaho and Montana, in Schmidt, C.J.

and Perry, W.J., Jr., eds., Interaction of the Rocky Mountain

foreland and the Cordilleran thrust belt: Geological Society of

cykowski, A.M., and Winters, R.A., 1988, Mineral resources

of the Eighteenmile Wilderness Study Area, Lemhi County,

nary geologic map of the Edie Ranch quadrangle, Clark

County, Idaho, and Beaverhead County, Montana: U.S. Geo-

logical Survey Open-File Report 79–845, scale 1:62,500.

mountain seismic belt, in Slemmons, D.B., Engdahl, E.R., Zo-

America: Boulder, Colo., Geological Society of America, Dec

ade Map Volume to Accompany the Neotectonic Maps, Part

of the Continent-Scale Maps of North America, p. 185–228.

rangle, Lemhi County, Idaho, and Beaverhead County, Mon-

tana: U.S. Geological Survey Geologic Quadrangle Map

rium district, Idaho and Montana: U.S. Geological Survey

extensional history of the late Cenozoic Basin and Range

province, western North America, in Faulds, J.E., and Stew-

art, J.H., eds., Accommodation zones and transfer

zones—The regional segmentation of the Basin and Range

province: Geological Society of America Special Paper 323,

Faulds, J.E., Ferrari, L., Grose, T.L.T., Henry, C.D., Janecke,

S.U., Miller, D.M., Richard, S.M., Rowley, P.D., Roldan-Quin-

tana, J., Scott, R.B., Sears, J.W., and Williams, V.S., 1998,

Map showing Cenozoic tilt domains and associated structural

features, western North America, in Faulds, J.E., and Stew-

art, J.H., eds., Accommodation zones and transfer

zones—The regional segmentation of the Basin and Range

province: Geological Society of America Special Paper 323,

Quaternary faulting of the northern Basin and Range prov-

ince, Montana and Idaho: Bulletin of the Seismological Soci-

Stickney, M.C., and Bartholomew, M.J., 1987, Seismicity and late

Tysdal, R.G., 1996a, Geologic map of adjacent areas in the Hay-

den Creek and Mogg Mountain quadrangles, Lemhi County,

Idaho: U.S. Geological Survey Miscellaneous Investigations

—1996b, Geologic map of the Lem Peak quadrangle, Lemhi

Tysdal, R.G., and Moye, Falma, 1996, Geologic map of the Alli-

County, Idaho: U.S. Geological Survey Geologic Quadrangle

son Creek quadrangle, Lemhi County, Idaho: U.S. Geological

Survey Geologic Quadrangle Map GQ-1778, scale 1:24,000.

evolution of the Horse Prairie half graben, southwest Monta-

na: Logan, Utah, Utah Sate University M.S. thesis, 152 p., 2

Three-dimensional strain produced by >50 My of episodic ex-

tension, Horse Prairie basin area, SW Montana, U.S.A

Journal of Structural Geology, v. 20, no. 12, p. 1747–1767.

U.S. Cordillera, in Burchfiel, B.C., Lipman, P.W., and Zo-

back, M.L., eds., The Cordilleran Orogen—Conterminous

U.S.: Boulder, Colo., Geological Society of America, The Ge-

southwestern Montana and adjacent Idaho: U.S. Geological

Survey Miscellaneous Investigations Series Map I-890, scale

Beaverhead County, Montana: Boulder, Colo., University of

Wernicke, Brian, 1992, Cenozoic extensional tectonics of the

Witkind, I.J., 1975, Geology of a strip along the Centennial fault,

Zimbelman, D.R., 1984, Geology of the Polaris 1SE quadrangle,

ology of North America, v. G-3, p. 553-581.

Colorado M.S. thesis, 158 p.

ety of America, v. 77, no. 5, p. 1602–1625.

Series Map I–2563, scale 1:24,000.

Map GQ-1777, scale 1:24,000.

Stewart, J.H., Anderson, R.E., Aranda-Gomez, J.J., Beard, L.S.

Stewart, J.H., 1998, Regional characteristics, tilt domains, and

Staatz, M.H., 1973, Geologic map of the Goat Mountain quad-

Professional Paper 1049–A, 90 p., 2 plates.

GQ-1097, scale 1:24,000.

back, M.D., and Blackwell, D.D., eds., Neotectonics of North

Smith, R.B., and Arabasz, W.J., 1991, Seismicity of the Inter-

Idaho: U.S. Geological Survey Bulletin 1718-B, p. B1-B21

Skipp, Betty, 1984, Geologic map and cross sections of the Italian

vey Open-File Report 85–545, 170 p., 3 plates.

● ——1988, Cordilleran thrust belt and faulted foreland in the Bea

Skipp, Betty, Hassemer, J.R., Kulik, D.M., Sawatzky, D.L., Lesz

MF-1061-B, scale 1:62,500.

America Memoir 171, p. 237–266.

Idaho: Bulletin of the Seismological Society of America, v

Schmidt, C., Sheedlo, Mark, Werkema, Michael, 1984, Control of

Scholten, Robert, Keenmon, K.A., and Kupsch, W.O., 1955, Ge-

Scholten, Robert, and Ramspott, L.D., 1968, Tectonics mecha

Special Paper 104, 70 p., 6 plates, scale 1:62,500.

Scott, W.E., Pierce, K.L., and Hait, M.H., Jr., 1985, Quaternary

Sears, J.W., 1995, Middle Miocene rift system in SW Monta-

Pierce, K.L., and Morgan, L.A., 1992, The track of the Yellow

Reynolds, M.W., 1979, Character and extent of Basin-Range

Rodgers, D.W., and Janecke, S.U., 1992, Tertiary paleoge

Mountain Association of Geologists, p. 185–193.

graphic maps of the western Idaho-Wyoming-

America Memoir 179, p. 1–53.

southwestern Montana: Kalamazoo, Mich., Western Michigan

McBride, B.C., 1988, Geometry and kinematics of the central

west Montana: Montana Bureau of Mines and Geology Open-

Idaho: Geology, v. 28, no. 5, p. 439–442.

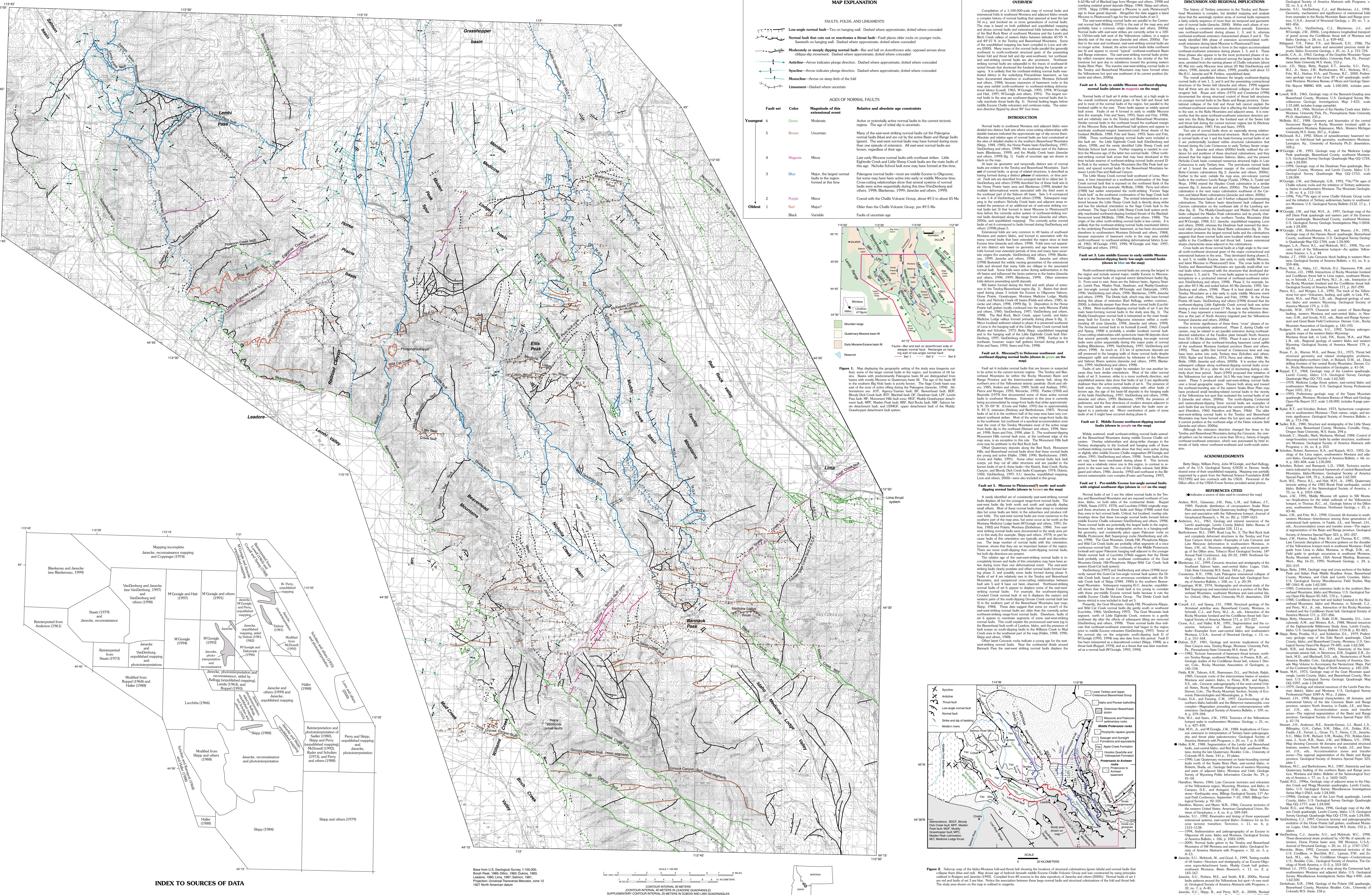
vania State University M.S. thesis, 153 p.

1:31,680, includes 6-page pamphlet.

University M.S. thesis, 267 p., 8 plates.

Ph.D. dissertation, 235 p.

Janecke, S.U., VanDenburg, C.J., and Blankenau, J.J., 1998



age to these gravel deposits. Altogether the data suggest a latest head Mountains is complex, but detailed mapping and analysis nial normal fault (Witkind, 1975) to the east of the map area and sets of normal faults (Janecke, 2000). Within each phase of norprobably have a common origin (Janecke and others, 2000a). mal faulting a consistent extension direction prevails. Extension Normal faults with east-west strikes are currently active in a 100- was northeast-southwest during phases 1, 3, and 6, whereas to 150-km-wide belt west of the Yellowstone caldera, in a region northwest-southeast extension characterized phases 2 and 4. The directly east of the map area (Janecke and others, 2000a). Far-newly identified fifth phase of extension accommodated northther to the west and northwest, east-west-striking normal faults are south extension during latest Miocene to Pleistocene(?) time. (set 6) and appear to record "typical" northeast-southwest Basin northeast-southwest extension during phases 1, 3, and 6. These and Range extension. The east-west-striking normal faults probathree phases also appear to be the most protracted phases of exbly reflect transient stress reorientation in the vicinity of the Yeltension. Phase 3, which produced among the largest faults in the lowstone hot spot due to subsidence toward the growing eastern area, persisted from the waning phases of Challis volcanism (about Snake River Plain. The inactive east-west-striking normal faults in 45 Ma) into early Miocene time (about 20 Ma) (VanDenburg and Dunn, J.D., Skipp, Betty, Ruppel, E.T., Janecke, S.U., Perr the Tendoy and Beaverhead Mountains may have formed when others, 1998; Janecke and others, 1999), possibly until about 15 the Yellowstone hot spot was southwest of its current position (Ja-Ma (S.U. Janecke and M. Perkins, unpublished data).

the overall northwest structural grain of the fold and thrust belt on younger normal faults in the Basin and Range province. Graviand to most of the normal faults of the region, but parallel to the tational collapse of the fold and thrust belt cannot explain the foreland uplifts to the east. These faults appear as widely spaced northeast-southwest extension that is affecting the foreland farther fault zones. Faults of set 4 formed in early to middle Miocene to the east, in the Ruby Mountains and adjacent areas. It is notetime (for example, Fritz and Sears, 1993; Sears and Fritz, 1998), worthy that the same northeast-southwest extension direction perand are relatively rare in the Tendoy and Beaverhead Mountains. sists into the Ruby Range in the foreland east of the Sevier fold Similar normal faults to the northeast bound the southeast margin and thrust belt during the current tectonic regime (set 6) (Stickney of the Miocene Ruby and Beaverhead half grabens and appear to and Bartholomew, 1987; Fritz and Sears, 1993). reactivate southeast-vergent basement-cored thrust sheets of the Two sets of normal faults show an especially strong relationforeland (McBride, 1988; Fritz and Sears, 1993; Sears and Fritz, ship with preexisting contractional structures. Both the prevolcaneast-striking normal fault zones that may have developed at this showed that the region between Salmon, Idaho, and the present time include swarms of northeast-striking normal faults around Ellis Peak in the western Tendoy Mountains (the Ellis Peak fault system), and spaced normal faults in the Beaverhead Mountains be-The Little Sheep Creek normal fault southwest of Lima, Mon-Farther to the west, outside the map area, pre-volcanic normal tana, is here interpreted as a southwest continuation of the Sage faults in the northern Lemhi Range (Tysdal, 1996a, b; Tysdal and Creek normal fault that is exposed on the northwest flank of the Moye, 1996) extend the Hayden Creek culmination in a similar Snowcrest Range (for example, McBride, 1988). Perry and others manner (fig. 2; Janecke and others, 2000c). The Hayden Creek

6.62-Ma tuff of Blacktail (age from Morgan and others, 1998) and overlying undated gravel deposits (Skipp, 1984; Skipp and others, 1979). Skipp (1984) assigned a Pliocene to early Pleistocene(?) The east-west-striking normal faults are parallel to the Centenno longer active. Instead, the active normal faults strike northwest

Widely scattered, small northeast-striking normal faults extend
Tendoy and Beaverhead Mountains during the Cenozoic, the overed the Beaverhead Mountains during middle Eocene Challis volcanism. Overlap relationships and along-strike changes in the northeast-southwest extension, which was punctuated by brief in-Tertiary stratigraphy in the footwall and hanging walls of these tervals of fairly minor northwest-southeast and north-south extennortheast-striking normal faults show that they were active during sion. event was a relatively minor one in this region, in contrast to regions to the west near the core of the Challis volcanic field (Kiils- each of the U.S. Geological Survey (USGS) in Denver, kindly gaard and others, 1986; Janecke, 1992) and northwest in the Bit-shared some of their unpublished mapping. Mapping was partially **Fault set 1. Pre-middle Eocene low-angle normal faults**Dillon office of the USDA Forest Service provided aerial photos.

Normal faults of set 1 are the oldest normal faults in the Tendoy and Beaverhead Mountains and are exposed northeast of Leaped these structures as thrust faults and Skipp (1988) noted that they were in fact normal faults. Critical, but localized, overlap relationships show that these low-angle normal faults formed before middle Eocene Challis volcanism (VanDenburg and others, 1998). • Anderson, A.L., 1961, Geology and mineral resources of the These normal faults are potentially the largest faults in the region, because they omit a large stratigraphic section in a hanging-wallflat geometry, and consistently place upper Paleozoic rocks on Bartholomew, M.J., 1989, Road Log No. 2, The Red Rock fault Middle Proterozoic Belt Supergroup rocks (VanDenburg and othand Wild Cat Creek faults are probably offset segments of a once continuous normal fault. The continuity of the Middle Proterozoic footwall and upper Paleozoic hanging wall adjacent to the younger Divide normal fault of Lucchitta (1966) suggests that the Divide fault probably cuts out the southeast continuation of the Goat Mountain-Grizzly Hill-Phosphoria Klippe-Wild Cat Creek fault

Blankenau, J.C., 1999, Cenozoic structure and stratigraphy of the VanDenburg (1997) and VanDenburg and others (1998) incorrectly named this Goat-Cat low-angle normal fault system the Divide Creek fault, based on an erroneous correlation with the Divide Creek fault of Skipp (1984, 1985) in the southern Beaver-

Presently, the Goat Mountain, Grizzly Hill, Phosphoria Klippe, Ocryell, J.J., and Spang, J.H., 1988, Structural geology of the (VanDenburg and others, 1998). These normal faults thus indi-M'Gonigle (1993, 1994) may also date from this period. Fault D 2, p. 151–164.

> 4, p. 379–394. 1121–1138.

The history of Tertiary extension in the Tendoy and Beavershow that the seemingly random array of normal faults represents a fairly orderly sequence of more than six temporal and geometric The largest normal faults to form in the region accommodated

The overall parallelism between the largely southwest-dipping normal faults of sets 1, 3, and 6 and the preexisting contractional structures of the Sevier belt (Janecke and others, 1999) suggests that all three sets are due to gravitational collapse of the Sevier orogenic belt. Royse and others (1975) and Constenius (1996) ● Lowell, W.R., 1965, Geologic map of the Bannack-Grayling area documented the strong structural control of thrust belt structures Lucchitta, B.K., 1966, Structure of the Hawley Creek area, Idaho ● McDowell, R.J., 1992, Effects of synsedimentary basement te • M'Gonigle, J.W., 1993, Geologic map of the Medicine Lodge

■ ——1994, Geologic map of the Deadman Pass quadrangle, Bea verhead County, Montana, and Lemhi County, Idaho: U.S. Butte-Carmen culminations (fig 2; Janecke and others, 2000c). Geological Survey Quadrangle Map GQ-1753, scale M'Gonigle, J.W., and Dalrymple, G.B., 1993, 40Ar/39Ar ages of Challis volcanic rocks and the initiation of Tertiary sedimentary basins in southwestern Montana: The Mountain Geologist, v. 30, no. 4, p. 112–118. ● ——1996, ⁴⁰Ar/³⁹Ar ages of some Challis Volcanic Group rocks The detachment faults of set 3 further collapsed the preexisting and the initiation of Tertiary sedimentary basins in southwestern Montana: U.S. Geological Survey Bulletin 2132, 17 p., 1 Jeff Davis Peak quadrangle and eastern part of the Everson Creek quadrangle, Beaverhead County, southwest Montana: U.S. Geological Survey Geologic Investigations Map I–2604 ● M'Gonigle, J.W., Kirschbaum, M.A., and Weaver, J.N., 1991 Geologic map of the Hansen Ranch quadrangle, Beaverhead County, southwest Montana: U.S. Geological Survey Geologic Quadrangle Map GQ-1704, scale 1:24,000. Morgan, L.A., Pierce, K.L., and McIntosh, W.C., 1998, The vol-Cross faults are those normal faults at a high angle to the overcanic track of the Yellowstone hotspot—An update: Yellow all north-northwest structural grain of the major contractional and stone Science, v. 5, p. 44.

4, and 5, in middle Eocene, late early to early middle Miocene, and latest Miocene to Pleistocene(?) time. The cross faults in the Tendoy and Beaverhead Mountains are typically small-offset norsubsequent collapse along northwest-dipping normal faults occureast-west-striking normal faults in the Tendoy and Beaverhead Mountains may have formed when the hot spot was southwest of it current position at the northeast edge of the Heise volcanic field • Sadler, R.K., 1980, Structure and stratigraphy of the Little Sheep (Janecke and others, 2000a). Although the extension direction changed five times in the

Betty Skipp, William Perry, John M'Gonigle, and Karl Kellogg supported by a grant from the National Science Foundation (EAR 9317395) and two contracts with the USGS. Personnel of the

[■ indicates a source of data used to construct the map]

1989, Parabolic distribution of circumeastern Snake River Plain seismicity and latest Quaternary faulting—Migratory pattern and association with the Yellowstone hotspot: Journal of Geophysical Research, v. 94, no. B2, p. 1589–1621. Lemhi guadrangle, Lemhi County [Idaho]: Idaho Bureau of Mines and Geology Pamphlet 124, 111 p. and complexly deformed structures in the Tendoy and Four Eyes Canyon thrust sheets—Examples of Late Cenozoic and Late Mesozoic deformation in southwestern Montana, in Sears, J.W., ed., Structure, stratigraphy, and economic geology of the Dillon area, Tobacco Root Geological Society, 14th Annual Field Conference, July 20–22, 1989: Northwest Geology, v. 18, p. 21–35. Southeast Salmon basin, east-central Idaho: Logan, Utah, Utah State University M.S. thesis, 143 p., 2 plates. Constenius, K.N., 1996, Late Paleogene extensional collapse of the Cordilleran foreland fold and thrust belt: Geological Soci-

ety of America Bulletin, v. 108, no. 1, p. 20–39. Belt Supergroup and associated rocks in a portion of the Beaverhead Mountains, southwest Montana and east-central Idaho: Oxford, Ohio, Miami University Ph.D. dissertation, 224

Armstead anticline area, Beaverhead County, Montana, in Schmidt, C.J., and Perry, W.J., Jr., eds., Interaction of the Rocky Mountain foreland and the Cordilleran thrust belt: Geological Society of America Memoir 171, p. 217–227. seismic behavior of Basin and Range normal faults—Examples from east-central Idaho and southwestern Montana, U.S.A.: Journal of Structural Geology, v. 13, no. Skipp, Betty, Prostka, H.J., and Schleicher, D.L., 1979, Prelimi-Deer Canyon area, Tendoy Range, Montana: University Park, Pa., Pennsylvania State University M.S. thesis, 87 p.

● ——1982, Tectonic framework of basement thrust terrane, north-

ern Tendoy Range, southwest Montana, in Powers, R.B., ed., Geologic studies of the Cordilleran thrust belt, volume I: Denver, Colo., Rocky Mountain Association of Geologists, p. Fields, R.W., Tabrum, A.R., Rasmussen, D.L., and Nichols, Ralph, 1985, Cenozoic rocks of the intermontane basins of western Montana and eastern Idaho, in Flores, R.M., and Kaplan, S.S., eds., Cenozoic paleogeography of the west-central United States, Rocky Mountain Paleogeography Symposium 3:

——1979, Geology and mineral resources of the Lemhi Pass tho-Denver, Colo., The Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, p. 9–36.

Foster, D.A., and Fanning, C.M., 1997, Geochronology of the northern Idaho batholith and the Bitterroot metamorphic core complex—Magmatism preceding and contemporaneous with extension: Geological Society of America Bulletin, v. 109, no. Fritz, W.J., and Sears, J.W., 1993, Tectonics of the Yellowstone hotspot wake in southwestern Montana: Geology, v. 21, no. Hait, M.H., Jr., and M'Gonigle, J.W., 1988, Implications of Cenozoic extension to interpretation of Tertiary basin paleogeography and thrust plate paleotectonics: Geological Society of America Abstracts with Programs, v. 20, no. 7, p. A–108. • Haller, K.M., 1988, Segmentation of the Lemhi and Beaverhead faults, east-central Idaho, and Red Rock fault, southwest Montana, during the late Quaternary: Boulder, Colo., University of Colorado M.S. thesis, 141 p., 10 plates. ——1990, Late Quaternary movement on basin-bounding normal faults north of the Snake River Plain, east-central Idaho, in Roberts, Sheila, ed., Geologic field tours of western Wyoming and parts of adjacent Idaho, Montana and Utah: Geologic Survey of Wyoming Public Information Circular No. 29, p. Hamilton, Warren, 1960, Late Cenozoic tectonics and volcanism of the Yellowstone region, Wyoming, Montana, and Idaho, in Campau, D.E., and Anisgard, H.W., eds., West Yellow-

stone—Earthquake area, Billings Geological Society 11th Annual Field Conference, September 7–10, 1960: Billings Geological Society, p. 92–105. Hamilton, Warren, and Myers, W.B., 1966, Cenozoic tectonics of the western United States: American Geophysical Union, Reviews of Geophysics, v. 4, no. 4, p. 509–549. Janecke, S.U., 1992, Kinematics and timing of three superposed extensional systems, east-central Idaho—Evidence for an Eo- VanDenburg, C.J., 1997, Cenozoic tectonic and paleogeographic cene tectonic transition: Tectonics, v. 11, no. 6, p. ——1994, Sedimentation and paleogeography of an Eocene to Oligocene rift zone, Idaho and Montana: Geological Society

VanDenburg, C.J., Janecke, S.U., and McIntosh, W.C., 1998, of America Bulletin, v. 106, p. 1083–1095. —2000, Normal faults galore in the Tendoy and Beaverhead Mountains of SW Montana and eastern Idaho: Geological Society of America Abstracts with Programs, v. 32, no. 5, p. Janecke, S.U., McIntosh, W., and Good, S., 1999, Testing models of rift basins—Structure and stratigraphy of an Eocene-Oligocene supra-detachment basin, Muddy Creek half graben,

southwest Montana: Basin Research, v. 11, no. 2, p. Janecke, S.U., Perkins, M.E., and Smith, R.B., 2000a, Normal faults patterns around the Yellowstone hot spot—A new model: Geological Society of America Abstracts with Programs, v. 32, no. 7, p. A-45. Janecke, S.U., Skipp, B., and Perry, W.P., Jr., 2000b, Revised thrust fault patterns in the Tendoy Mountains of SW MT:

> Manuscript approved for publication April 6, 2001 Any use of trade names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey This map was produced on request, directly from digital files, on an electronic plotter For sale by U.S. Geological Survey Information Services Box 25286, Federal Center, Denver, CO 80225 1-888-ASK-USGS A PDF for this map is available at http://geology.cr.usgs.gov/greenwood-pubs.html

NATIONAL GEODETIC VERTICAL DATUM OF 1929