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OPHIOLITIC TERRANES OF EAST-CENTRAL AND SOUTHWESTERN ALASKA

by

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INTRODUCTION

This is one of a series of open-file reports that present the results of a comprehensive study of the ophiolitic terranes of Alaska and contiguous parts of northeast Russia. The study was carried out by the U.S. Geological Survey, the Alaska Division of Geological and Geophysical Surveys, and the Far East Branch of the Academy of Sciences of the USSR between 1989 and 1991. Other reports that have been placed in open-file in this series are a geologic map of the ophiolitic terranes of Alaska (Patton and others, 1992), a map of the ophiolitic and other mafic-ultramafic metallogenic provinces in Alaska (Foley, 1992), and summaries of the lithology, thickness, age, geochemistry, and geologic setting of the major ophiolitic terranes in Alaska (Nelson, 1992; Patton, 1992a,b; Burns, 1992). This report focuses on the ophiolitic terranes of east-central and southwestern Alaska. For location of specific geographic and geologic features mentioned in this report and for information on the regional geologic setting of this and the other ophiolitic terranes of Alaska, the reader should consult Open-File Report 92-20A in this series by Patton and others (1992).

This report greatly benefitted from suggestions for improvement by Cynthia Dusel-Bacon, and Warren Nokleberg.

Definition of terms

The term *ophiolite*, as used in this report, follows the definitions of Steinmann (1927) and the Geological Society of America Penrose Conference on ophiolites (Penrose Field Conference, 1972). The term refers to an association of mafic and ultramafic rocks that, in a complete sequence, is characterized from bottom to top by tectonized ultramafic rock, a transitional zone of interlayered ultramafic and mafic cumulates, layered gabbro, massive gabbro, a mafic sheeted dike complex, and pillow basalt. Most workers now regard ophiolite assemblages as allochthonous fragments of oceanic crust and upper mantle that formed along mid-ocean ridges, in small marginal basins, or as basement to island arcs (see, for example, International Atlas of Ophiolities, 1979). The ophiolitic terranes of east-central and southwestern Alaska have been emplaced or "obducted" onto older continental crust and are characteristic of the "Tethyan-type" ophiolite as defined by Moores (1982) and Coleman (1984). The geologic setting of these ophiolitic terranes contrast with the the "Cordilleran-type" ophiolitic terranes in southern Alaska, which characteristically have been underthrust by younger accretionary flysch deposits. *Ophiolitic terranes* are defined in this series of reports as fault-bounded belts of oceanic rocks that contain ophiolite complexes.

EAST-CENTRAL ALASKA

OPHIOLITIC TERRANE

The ophiolitic terrane of east-central Alaska is located in the Yukon-Tanana Upland (pl. 1, col. F) and has been designated the Seventymile lithotectonic terrane by Jones and others (1987). It consists of a number of small allochthonous bodies of oceanic rocks that structurally overlie metasedimentary and metavolcanic rocks assigned to the Yukon-Tanana terrane by Jones and others (1987) and, in the east-central part of the Upland, to the Stikinia terrane by Nokleberg and others (1991). The allochthonous ophiolitic bodies of the Seventymile terrane are distributed along a broad belt that extends from the Alaska-Canada boundary westward to the vicinity of Fairbanks. Aeromagnetic data (Decker and Karl, 1977) suggest that the belt continues in the subsurface southwestward across the Tanana River to a small exposure of ultramafic rocks in the alluviated lowlands about 40 km south of Fairbanks. The allochthonous bodies comprising the Seventymile terrane are interpreted to be remnants of a vast sheet of oceanic rocks that overrode the Yukon-Tanana and Stikinia terranes in Mesozoic time (Foster and others, 1987) Sparse occurrences of glaucophane in the vicinity of these klippe are thought to be related to high-pressure metamorphism that accompanied subduction and underthrusting of the Yukon-Tanana terrane (Dusel-Bacon and others, in press).

The exact timing and direction of tectonic transport and the location of the root zone of the oceanic rocks are controversial. Some workers argue that the Seventymile terrane was derived from an ocean basin that separated the Yukon-Tanana terrane from the North American continental margin along the present site of the Tintina fault (Keith and others, 1981); other workers suggest that it represents remnants of a small ocean basin that separated two subterranes within the Yukon-Tanana terrane (Foster and others, 1987); and still others propose that the Seventymile terrane was derived from an ocean basin that separated an outboard arc from the western margin of North America (Hansen and others, 1991; Dusel-Bacon and Hansen, in press). Pavlis and others (written commun., 1990) suggest that the present basal fault contact of the ophiolitic rocks is an extensional detachment fault of mid-Cretaceous age formed along an older thrust fault.

A composite section of the Seventymile terrane exposed in the Salcha River and Mount Sorenson areas appears to be composed of three structural panels (Nokleberg, W.J. and others, written commun., 1989; Keith and others, 1981; Southworth, 1984a) (pl. 1, col. A).

The upper panel is estimated to be about 750m thick and consists of serpentinized harzburgite and dunite with minor clinopyroxenite and massive and cumulus gabbro. Foster and others (1987) have tentatively assigned this complex a late Paleozoic to Jurassic age based on the occurrence of Carboniferous to Late Triassic fossils in the oceanic rocks of the lower panel and on an Early to Middle Jurassic ^{40}Ar-^{39}Ar age of 186±2 Ma (Cushing and others, 1984) obtained from an undeformed dike that intrudes regionally metamorphosed rocks belonging to the underlying Stikinia terrane in the east-central part of the Yukon-Tanana Upland (pl. 1, col. C). Presumably the undeformed dike postdates the emplacement of the Seventymile terrane and thereby constrains the age of the upper panel to Middle Jurassic or older. The base of the upper panel generally is marked by a highly tectonized metamorphic sole as much as 30m thick of amphibolite and mylonitic schist with zones of rodingite and silica-carbonate. The metamorphic sole may be related to emplacement of the ophiolitic complex above the oceanic crustal rocks that comprise the lower two thrust panels (pl. 1, col. A), but Pavlis and others (1988) indicate that similar mylonitic zones nearby are related, at least in part, to detachment faulting of mid-Cretaceous age. According to Foster and others (1987), the time of emplacement is probably Early Jurassic and is constrained by the presence of Late Triassic fossils in the lower thrust panels and by the Middle Jurassic or older age assignment of the ophiolitic complex. No trace element or rare-earth element geochemical data are available for the ultramafic-mafic rocks in the upper panel.

The middle panel is composed of pillow basalt and basaltic tuff that have been altered to greenstone of lower greenschist metamorphic facies. No thickness, age, or geochemical data have been published for these basaltic rocks and it is uncertain if they are mid ocean ridge-, seamount-, or volcanic arc -related.

The lower panel consists of chert, argillite, limestone, graywacke, conglomerate, meta-andesite and minor greenstone layers metamorphosed to lower greenschist facies. This assemblage contains Carboniferous to Late Triassic radiolarians and Late Triassic megafossils (Foster and others, 1987).

UNDERLYING CONTINENTAL ROCKS

The Yukon-Tanana Upland is underlain chiefly by metasedimentary, metavolcanic and metagranitic rocks of the Yukon-Tanana terrane, which are interpreted as an assemblage of continental margin and continental igneous arc rocks of Proterozoic(?) to mid-Paleozoic age (Foster and others, 1987; Nokleberg and others, 1989). The Yukon-Tanana terrane is composed primarily of quartzitic and pelitic schist, felsic gneissic and metavolcanic rocks, and sparse marble and greenstone that were regionally metamorphosed from lower greenschist to upper amphibolite facies in the Late Triassic to mid-Cretaceous (Foster and others, 1987; Nokleberg and others, 1989). The Yukon-Tanana terrane was widely intruded by granitic plutons in mid and Late Cretaceous and early Tertiary.

The east-central part of the Upland also includes a smaller area of granitic intrusive rocks and associated metamorphic wallrocks, which have been assigned to the Stikinia terrane by Nokleberg and others (1991) and are interpreted by them as an island arc assemblage of late Paleozoic and early Mesozoic age. Although we also refer these rocks to the Stikinia terrane, Dusel-Bacon and Hansen (in press) assign them to a separate terrane, the Taylor Mountain terrane. They point out that, although these rocks include granitoids of latest Triassic to Early Jurassic age like the Stikinia terrane in Canada, the associated wallrocks appear to have had a different thermal history and may have different protolith ages. The Stikinia terrane of east-central part of the Upland, as defined in this report, consists of: 1) Paleozoic quartzitic and pelitic gneiss and schist, quartzite, marble, and amphibolite that were metamorphosed under high-pressure amphibolite conditions in the Early Jurassic, and 2) latest Triassic and Early Jurassic granitic plutons of the Taylor Mountain batholith that do not display the mid-Cretaceous metamorphism of the subjacent Yukon-Tanana terrane.

The Seventymile terrane structurally overlies both the Yukon-Tanana and Stikinia terranes, but it is not clear if either the Early Jurassic or the Cretaceous metamorphic event is related to the emplacement of the ophiolitic assemblage. Nokleberg and others (1991) suggest that the ophiolitic assemblage of the Seventymile terrane and the island arc assemblage of the Stikinia terrane were emplaced on the continental rocks of the Yukon-Tanana terrane in Late Jurassic. However, other workers (Hansen and others, 1991; Dusel-Bacon and Hansen, in press; Foster and others, 1987) prefer an Early Jurassic emplacement age based on the observed structural relationships between the Stikinia and Seventymile terrane.

SOUTHWESTERN ALASKA

The ophiolitic terrane of southwestern Alaska, as defined in this report, is an assemblage of oceanic rocks that compose the lower part of the Togiak and all of the Goodnews lithotectonic terranes of Jones and others (1987) (pl. 2, col. A). The ophiolitic terrane forms a mappable unit that can be distinguished from the structurally overlying arc volcanic rocks that form the upper part of the Togiak terrane and from the structurally underlying cratonal rocks of the Kilbuck lithotectonic terrane of Jones and others (1987). Mafic-ultramafic complexes, which occur as thrust sheets in the disrupted base of the Togiak terrane, make up the upper part of the ophiolitic terrane. They form structural klippe that rest on an imbricated assemblage of oceanic crustal rocks belonging to the Goodnews terrane (Box, 1985a,b). The original thrust relationship at the base of the klippe has been extensively overprinted by low-angle extensional faulting, indicated by the abrupt juxtaposition of low-grade over high-grade metamorphic rocks (Box, 1985b) The ophiolitic terrane, in turn, has been thrust onto the Kilbuck terrane, a cratonal assemblage of Early Proterozoic age (Box and others, 1990) (pl. 2, col. A). The well-known, platinum-bearing mafic-ultramafic bodies near Goodnews Bay (Mertie, 1940; Bird and Clark, 1976; Southworth, 1984b) are interpreted to be zoned intrusives and are not considered to be part of ophiolite complexes.

OPHIOLITIC TERRANE

The mafic-ultramafic ophiolite complexes in the upper part of the ophiolitic terrane consist of about 90 percent nonlayered gabbro and pillow basalt and 10 percent serpentinized harzburgite and dunite (pl. 2, col. A). The pillow basalt and gabbro are spatially associated with the ultramafic rocks and, although contacts are everywhere faulted, the pillow basalt and gabbro are interpreted as higher levels of the same ophiolite succession. The pillow basalt is interlayered with chert that contains Late Triassic radiolarians. The ultramafic-gabbroic rocks in the lower part of the complex are not dated directly, but are inferred to be roughly cogenetic with the basalt and chert. The mafic-ultramafic complexes are overlain by a thick volcanic-arc assemblage of andesitic volcanic and volcaniclastic strata comprising the upper part of the Togiak terrane as defined by Jones and others (1987). This volcanic-arc assemblage yields fossils ranging in age from Late Triassic to Early Cretaceous. The mafic-ultramafic ophiolite complexes are interpreted by Box (1985a,b) to form the foundation upon which this volcanic-arc assemblage was deposited.

Sparse geochemical data from pillow basalt, diabase, and gabbro in the upper part of the ophiolite complexes (Box, 1989) are shown in chondrite-normalized spiderdiagrams and REE (rare-earth-element) plots on pl. 2, col. E. Many more analytical data are needed to define the tectonic setting in which these volcanic and subvolcanic rocks formed, but the available trace element and REE data suggest that they are not subduction-related. The spiderdiagrams do not show the marked depletion of Nb and Ta relative to La or the high contents of large-ion-lithophile elements (Ba, K, Rb, Sr, Th) that are characteristic of magmas associated with convergent margins. Samples of pillow basalt (from the uppermost part of the complex) and from a diabase dike are moderately enriched in LREE (light-rare-earth-elements), whereas samples of the pillow basalt (from slightly lower levels of the complex), diabase sills, and a gabbro body show slightly depleted LREE abundances. The spiderdiagram and REE patterns are generally compatible with a mid-ocean ridge, a backarc basin, or an oceanic intraplate tectonic setting.

The above described mafic-ultramafic ophiolite complexes are underlain by an imbricated assemblage of oceanic rocks that makes up the Goodnews lithotectonic terrane of Jones and others (1987) (pl. 2, col. A). The structurally highest part is composed of three schistose nappes characterized by transitional greenschist-blueschist facies metamorphic rocks. The uppermost nappe consists chiefly of metabasalt, metagabbro, metachert, and metatuff; the lower two nappes are composed largely of metasedimentary rocks. The protolith age of these metamorphic rocks is uncertain, but metamorphism is presumed to have occurred in Late Triassic to Early Jurassic and to have been related to emplacement of the overlying ophiolite complex (Box, 1985b). The schistose nappes are structurally underlain by a wide array of oceanic rocks that have been only mildly altered to sub-greenschist metamorphic grade, chiefly prehnite-pumpellyite facies. These oceanic rocks occur in two northeast-trending belts separated by the Goodnews fault (pl. 2, col. F). The belt on the southeast side of the fault consists of unfoliated mafic flows, tuff, and volcaniclastic rocks, which contain fossils of Permian age. The belt on the northwest side is a melange composed of blocks and slices of radiolarian chert, basalt, laminated mudstone, and carbonate rocks, locally set in a scaly argillaceous matrix. The melange contains cherts ranging in age from Mississippian to Jurassic and blocks of carbonate rocks ranging in age from Ordovician to Triassic. The melange belt is underthrust along its northwest margin by metamorphosed cratonal rocks of the Early Proterozoic Kilbuck terrane. Scattered occurrences of transitional greenschist-blueschist facies schist along this fault suggest that high- to medium-pressure metamorphism was associated with the underthrusting.

UNDERLYING CONTINENTAL ROCKS

The Kilbuck terrane is an ancient cratonal fragment composed of a high-grade core of biotite-hornblende gneiss, granulite, amphibolite, schist, and lesser amounts of marble and quartzite, flanked by pelitic schist, quartzite, marble, and phyllite of greenschist facies metamorphic grade (Turner and others, 1983; Box and others, 1990) (pl. 2, col. A). Geochemical and isotopic data suggest that it probably represents an ancient island-arc assemblage (Moll-Stalcup and others, 1990). Two U-Pb zircon ages from an orthogneiss indicate an igneous protolith age of 2060 Ma (Early Proterozoic) (Box and others, 1990). K-Ar metamorphic mineral ages of 120-150 Ma reflect a regional overprinting probably related to Early Cretaceous underthrusting of these cratonal rocks beneath the ophiolitic terrane (Box, 1985c).

REFERENCES CITED IN TEXT AND TABLES

Aleinikoff, J.N., Dusel-Bacon, Cynthia, and Foster, H.L., 1986, Geochronology of augen gneiss and related rocks, Yukon-Tanana terrane, east-central Alaska: Geological Society of America Bulletin, v. 97, p. 626-637.

Anders, E. and Ebihara, M., 1982, Solar-system abundances of the elements: Geochim. Cosmochim. Acta, v. 46, p. 2263-2380.

Bird, M.L. and Clark, A.L., 1976, Microprobe study of olivine chromitites of the Goodnews Bay ultramafic complex, Alaska, and the occurrence of platinum: U.S. Geological Survey Journal of Research, v. 4, p. 717-725.

Box, S.E., 1985a,. Mesozoic tectonic evolution of the northern Bristol Bay region, southwestern Alaska: Santa Cruz, California, University of California, Ph.D. dissertation, 63 p.

Box, S.E., 1985b, Geologic setting of high-pressure metamorphic rocks, Cape Newenham area, southwestern Alaska, in Bartsch-Winkler, Susan, ed., The United States Geological Survey in Alaska: Accomplishments during 1984: U.S. Geological Survey Circular 967, p. 37-42.

Box, S.E., 1985c, Terrane analyses of the northern Bristol Bay region, southwestern Alaska, in Bartsch-Winkler, Susan, ed., The United States Geological Survey in Alaska: Accomplishments during 1984: U.S. Geological Survey Circular 967, p. 32-37.

Box, S.E., 1989, Togiak terrane, SW Alaska: Jura-Cretaceous arc built on Triassic oceanic crust: Geological Society of America Abstracts with Programs, v. 21, no. 5, p. 59.

Box, S.E., Moll-Stalcup, E.J., Wooden, J.L., and Bradshaw, J.Y., 1990, Kilbuck terrane: oldest known rocks in Alaska: Geology, v. 18, p.1219-1222.

Burns, L.E., 1992, Ophiolite complexes and associated rocks near the of the Border Ranges fault zone, southcentral Alaska: U.S. Geological Survey Open-File Report OF 92-20E.

Coleman, R.G., 1984, The diversity of ophiolites, in Zwart, H.J., Hartman, P., and Tobi, A.C., eds.: Ophiolites and ultramafic rocks - a tribute to Emile den Tex: Geologie en Mijnbouw 63. p. 141-150.

Cushing, G.W., Foster, H.L., Harrison, T.M., and Laird, Jo, 1984, Possible Mesozoic accretion in the eastern Yukon-Tanana Upland, Alaska: Geological Society of America Abstracts with Programs, v. 16, no. 6, p. 481.

Decker, J.E., and Karl, S.M., compilers, 1977, Preliminary aeromagnetic map of the eastern part of southern Alaska: U.S. Geological Survey Open-File Report 77-169-E, scale 1:1,000,000.

Dusel-Bacon, Cynthia and Hansen, V.L., in press, High-pressure amphibolite-facies metamorphism and deformation within the Yukon-Tanana and Taylor Mountain terranes, eastern Alaska, in Bradley, D.C. and Dusel-Bacon, Cynthia, eds., Geologic studies in Alaska by the U.S. Geological Survey, 1991: U.S. Geological Survey Bulletin __, 34 manuscript pages.

Dusel-Bacon, Cynthia, Csejtey, Béla, Foster, H.L., Doyle, E.O., Nokleberg, W.J., and Plafker, George, in press, Distribution, facies, ages, and proposed tectonic associations of regionally metamorphosed rocks in east- and south-central Alaska : U.S. Geological Survey Professional Paper 1497-C, 100 manuscript pages, 2 plates.

Foley, F.Y., 1992, Ophiolitic and other mafic-ultramafic metallogenic provinces in Alaska (west of the 141st meridian): U.S. Geological Survey Open-File Report OF 92-20B.

Foster, H.L., 1992. Geologic map of eastern Yukon-Tanana region, Alaska: U.S. Geological Survey Open-File Report 92-313, scale 1:500,000.

Foster, H.L., Keith, T.E.C., and Menzie, W.D., 1987, Geology of east-central Alaska: U.S. Geological Survey Open File Report 87-188.

International Atlas of Ophiolites, International Geologic Correlation Program Project 39 "Ophiolites of continents and comparable oceanic rocks": Geol. Soc. Am. Map and Chart Series MC-33, scale 1:2,500,000, 1979.

Hansen, V.L., Heizler, M.T., and Harrison, T.M., 1991, Mesozoic thermal evolution of the Yukon-Tanana composite terrane: New evidence from ^{40}Ar/^{39}Ar data: Tectonics, v.10, p. 51-76.

Jones, D.L., Silberling, N.J., Coney, P.J., and Plafker, G., 1987, Lithotectonic terrane maps of Alaska(west of the 141st Meridian): Folio of the lithotectonic terrane maps of the North American Cordillera: U. S. Geological Survey Miscellaneous Field Studies Map MF-1874-A, scale 1:2,500,000.

Keith, T.E.C., Foster, H.L., Foster, R.L., Post, E.V., and Lehmbeck, W.L., 1981, Geology of an alpine-type peridotite in the Mount Sorenson area, east-central Alaska, in Shorter contributions to general geology: U.S. Geological Survey Professional Paper 1170-A, p. A1-A9.

Mertie, J.B., Jr., 1940, The Goodnews platinum deposits, Alaska: U.S. Geological Survey Bulletin 918, 97 p.

Moll-Stalcup, E.J., Wooden, J.L., Bradshaw, J.Y., and Box, S.E. , 1990, A Sr, Nd, and Pb isotopic study of 2.07 Ga metaigneous rocks from the Kilbuck terrane, southwestern Alaska: Program with abstracts, Geological Association of Canada, Vancouver, Canada, May 16-18, 1990 , v. 15, p. A89.

Moores, E.M., 1982, Origin and emplacement of ophiolites: Review of Geophysics and Space Physics, v. 20, no. 4, p. 735-760.

Nokleberg, W.J., Foster, H.L., Lanphere, M.A. Aleinikoff, J.N.,and Pavlis, T.L., 1991, Structure and tectonics of the Yukon-Tanana, Wickersham, Seventymile and Stikinia terranes along the trans-Alaskan crustal transect (TACT), east-central Alaska: Geological Society of America Abstracts with Programs, v. 23, no. 2, p.84.

Nokleberg, W.J., Foster, H.L., and Aleinikoff, J.N., 1989, Geology of the northern Copper River Basin, eastern Alaska Range, and southern Yukon-Tanana Basin, southern and east-central Alaska, in Nokleberg, W.J. and Fisher, M.A., eds, Alaskan Geological and Geophysical Transect, Field trip guidebook T104: American Geophysical Union, Washington, D.C., p. 34-63.

Nokleberg, W.J., Bundtzen, T.K., Berg, H.C., Brew, D.A., Grybeck, Donald, Robinson, M.S., Smith, T.E., and Yeend, Warren, 1987, Significant metalliferous lode deposits and placer districts of Alaska: U.S. Geological Survey Bulletin 1786, 104 p.

Nelson, S.W., 1992, Ophiolite complexes of the Gulf of Alaska: U.S. Geological Survey Open-File Report OF 92-20C.

Patton, W.W., Jr., 1992a, Ophiolitic terrane of the western Brooks Range, Alaska: U.S. Geological Survey Open-File Report OF 92-20D.

Patton, W.W., Jr., 1992b, Ophiolitic terrane bordering the Yukon-Koyukuk basin, Alaska: U.S. Geological Survey Open-File Report OF 92-20F.

Patton, W.W., Jr., Murphy, J.M., Burns, L.E., Nelson, S.W., and Box, S.E., 1992, Geologic map of ophiolitic and associated volcanic arc and metamorphic terranes of Alaska (west of the 141st meridian): U.S. Geological Survey Open-File Report OF 92-20A.

Pavlis, T.L., Sisson, V.B., Nokleberg, W.J., Plafker, George, and Foster, Helen, 1988, Evidence for Cretaceous extension in the Yukon crystalline terrane, east-central Alaska [abs]: EOS (American Geophysical Union, Transactions), v. 69, p. 1453.

Penrose Field Conference, 1972, Ophiolites: Geotimes, v.17, no. 12, p. 24-25.

Southworth, D.D., 1984a, Geologic geochemical investigations of the "Nail" allochthon, east-central Alaska: U.S. Bureau of Mines Open-File Report 126-84, 19p.

Southworth, D.D., 1984b, Red Mountain: a southeastern Alaska-type ultramafic complex in southwestern Alaska: Geological Society of America Abstracts with Programs, v. 16, no. 5, p. 334.

Steinmann, G., 1927, Die ophiolitischen Zonen in der mediterranean Kettingebirgen: 14th International Geological Congress 2, p. 638-667.

Templeman-Kluit, D.J., 1979, Transported cataclasite, ophiolite and granodiorite in Yukon: evidence of arc-continental collision: Geological Survey of Canada Paper 79-14, p. 1-27.

Thompson, R.N., Morrison, M.A., Hendry, G.L., and Parry, S.J., 1984, An assessment of the relative roles of crust and mantle in magma genesis: An elemental approach: Philos. Trans. Royal Soc. London, Series A, v. 310, p. 675-692.

Turner, D.L., Forbes, R.B., Aleinikoff, J.N., Hedge, C.E., and McDougall, I., 1983, Geochronology of the Kilbuck terrane in southwestern Alaska: Geological Society of America Abstracts with Programs, v. 15, p. 407.