

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Provisional Geologic Map of Augustine Volcano, Alaska

by

Richard B. Waitt and James E. Begét
with contributions from Juergen Kienle

DESCRIPTION OF MAP UNITS

NOTE ON MAP-UNIT SYMBOLS

Most map units are divided mainly by age, which in prehistoric deposits is determined largely by presence of overlying marker beds in the form of coarse pumiceous tephra layers (fall deposits). Age of historic deposits is inferred from the absence of any of these beds and from various historic records, especially aerial photographs. The coarse pumiceous tephra layers are designated in ascending stratigraphic order: G, I, H, C, M, and B. All are late Holocene in age by radiocarbon dating (table 2). Prehistoric volcanic deposits are designated in time by the tephra layers between which they are inferred to lie, thus unit *HCas* lies above tephra layer H and below tephra layer C. Historic deposits are designated by the last two digits of the eruptions year, thus unit *83a* belongs to the 1883 eruption, unit *76p* to the 1976 eruption.

Internal contacts between some like-labeled units are units that will be distinguished on final (colored) version of map but are lumped together in this provisional version.

RECENT DEPOSITS

Beach deposits—Divided into:

- bs **Sandy**—Deposits of beach consisting mostly of moderately sorted loose medium to very coarse sand lying in tidal zone of about 7 m

- br **Rocky**—Deposits of beach consisting mostly of boulders, generally smaller than 2 m but in several places as large as 7 m in intermediate diameter and many also in cobble range. Most boulders and cobbles derive from debris-avalanche or pyroclastic deposits exposed in a sea cliff at back of beach

- t **Tidal-flat and salt-marsh deposits**—Flat expanses of sand, gravelly sand, and sandy gravel winnowed from adjacent deposits and frequently covered at medium to high tide in areas that seaward deposits defend against surf

- am **Marsh and pond alluvium**—Flat expanses of mud and sand in and along marshes and ponds on southwest part of island behind coastal deposits
- e **Eolian sand**—Loose, well-sorted medium to coarse sand forming coastwise ridge at back of beach above high-tide level. In places includes interbedded ash layers or peaty layers. In places includes identical underlying prehistoric deposits. In a few places, especially on southwest coast, is continuous downward into older eolian sand of unit *bed* (subdivided)
- ob **Offshore boulders**—Fields of angular boulders of porphyritic andesite, some of them >4 m in diameter, extending variously 0.2 to 1.5 km offshore. Many visible at low tides, and on aerial photographs expressed as conspicuous dark areas beneath the sea. Derived from coarse fragmental deposits of various ages. Seaward “contacts” delineate only where these deposits become too deep below sea level to show on aerial photographs or at lowest tides

DEPOSITS OF HISTORIC ERUPTIONS

Products of 1986 eruption—Divided into:

- 86d **Main lava dome**—Very dark gray (5YR 3/1) to reddish porphyritic andesite containing about 20 percent plagioclase phenocrysts as large as 5 mm and is microvescicular. Includes assimilated remnants of dome that had grown at same site in 1976. Geomorphically distinct north part of summit-dome complex
- 86a **Dome agglutinate**—Rampart composed of weakly welded clasts of porphyritic andesite, not present in photographs before 1986 eruption. A possible remnant (unmapped) of underlying 1976 dome consists of microvescicular gray (N 6/0) highly porphyritic andesite containing about 30 percent plagioclase phenocrysts as large as 4 mm
- 86pl **Deposits of lithic pyroclastic flow**—Lithic pyroclastic-flow deposits of large fan on north flank heading at dome. Consist mostly of fragments of porphyritic andesite dome rock but can have 0–30% pumice. Some large lithic blocks exceed 4 m in diameter. Overlaps pumiceous pyroclastic-flow deposit downslope
- 86pp **Deposits of pumiceous pyroclastic flow, mixed flow, and lahar**—Gravelly sand in which pumice clasts as large as 1 m but typically 10–25 cm, ranging from white to gray to brownish gray and containing 5–10% inconspicuous plagioclase phenocrysts; some pumice clasts conspicuously banded; some have “breadcrust” surface texture. Contains as much as 1/3rd angular lithic clasts generally smaller than 80 cm but in places including rare boulders as large as 2–4 m. Pumiceous flows have local surface relief as much as 1 m and steep margins 0.1 to 3 m high in digitate lobes, some as small as 3–10 m across; some flows have lateral levees 0.5–3 m high. Overlapped upslope by lithic pyroclastic-flow deposits. Most of deposits is gravelly sand; pumice boulders are concentrated at surface. In years 1988–1993 having only a few sprigs of grass, blueberry, and moss.
- Gravel lahar deposits grade downslope from pumiceous pyroclastic-flow deposit; range from matrix supported (debris-flow deposit) to openwork (flood deposit)

Products of 1976 eruption

- 76p **Deposits of pyroclastic flow and lahar**—Similar to such flows of 1986 (see above) but are especially rich (as much as 40%) in banded brown-gray-white pumice clasts. Lithic clasts of andesite (and locally of sandstone) as large as 1.4 m. In 1988–1993 had many clumps of grass, blueberry, and moss, 1 to 2 orders of magnitude more vegetation than on similar 1986 deposits but still very sparse (less than 5% of surface covered). In places such as lower west-southwest swale braided deposit veneers similar deposit of 1964 (and 1935?) more intricately than can be shown on map

Products of 1963–64 eruption—Divided into:

- 64d **Lava dome**—Gray (N 5/0) to reddish porphyritic andesite containing about 15 percent plagioclase phenocrysts as large as 3 mm. It is slightly microvesicular. Forms geomorphically distinct south rim (including summit) of summit-dome complex
- 64p **Deposits of pyroclastic flow and lahar**—Similar to pumiceous pyroclastic-flow deposit of 1986 and 1976 but much richer in lithic component and carrying larger lithic boulders. In places angular lithic boulders 0.5 to 2 m in diameter form much of surface, rare boulders are as large as 4 m. Internal lateral levees are common, some as high as 4 m. Deposits form broad paths leading nearly from base of dome to within 0.2 to 1.3 km of the coast. In contrast to younger (1986 and 1976) deposits, these (in 1991–95) are caked with moss and a few alder are established. Deposits in West-southwest swale may be partly of 1935 eruption

Products of 1935 eruption—Divided into:

- 35d **Lava dome**—Gray (N 5/0) to reddish porphyritic andesite with 15 percent plagioclase phenocrysts as large as 4 mm and a few dark rounded, finely crystalline xenoliths. Forms geomorphically distinct northwest part of summit dome complex and a western lobe
- 35b **Blocky rubble**—Coarse bouldery rubble in form of fan shed from summit dome. Perhaps partly of 1964 dome collapses

Products of 1883 eruption—Divided into:

- 83p **Deposits of pyroclastic flow and surge**—Massive poorly sorted lithic granular medium sand 0.3 to 2 m thick containing pebbles to 3 cm. Locally cut by upward-tapering fines-poor (gas-escape) pipes of small-pebble gravel. Capped by 10–20 cm of massive moderately sorted very-fine sand to silt ash. Smooth-surfaced, it overlies debris-avalanche deposit back from Burr Point, partly filling lows between hummocks. Overlapped in many places by 1976 and 1986 pyroclastic-flow deposits
- 83a **Debris-avalanche deposit**—Bouldery diamict including nearly intact but highly fractured blocks as large as 8 m in intermediate diameter (one is 25 m long!) and unfractured ones as large as 4 m. Matrix is sandy gravel of identical but finer-grained angular material. Jointing patterns are diversely irregular, platy, and columnar; rare blocks are of sintered spatter. Rare hummocks contain lenses of rounded pumice, apparently smeared-out clasts of pre-eruption pyroclastic-flow deposit. Rare hummocks contain yellow to brown blocks of soft, highly clay-altered andesite. Whole deposit is hummocky, individual hummocks being as high as 30 m and with basal diameter as much as 200 m, but typically 3–15 m high with basal diameters 20–80 m; some hummocks are arranged in curving arms. West side of deposit is marked by conspicuous nearly straight levee

descending from 650 to 40 m altitude. Hummocky deposit is locally overlain by as much as 10 cm of eolian sand and peat containing the distinctive white-silt fall ash as thick as 3 cm of Katmai 1912 eruption. Near the outer margins of overlapping 1976 and 1986 pyroclastic-flow deposits, ash-cloud silt overlies the hummocky deposit

Grouped pyroclastic and laharic deposits—Divided into:

- hu **Deposits of historic eruptions**—Muddy fall deposits (and pyroclastic-flow deposits?) of historic eruptions, nestled among 1935 and 1964 domes in summit area
- hpu **Pyroclastic-flow and lahar deposits of historic and prehistoric(?) eruptions**—Pumiceous to lithic coarse rubble on steep (18–25°) upper- to middle-level slopes descending from base of summit-dome complex. Variable surface and indefinite stratigraphy but apparently swept repeatedly. Insufficient evidence (capping tephra, vegetative cover, morphology) to differentiate by age. Includes a few patches of flowage and fall deposits of indeterminate age on lower flanks

PREHISTORIC HOLOCENE PRODUCTS

- bed **Beach and eolian deposits**—Area of about 1.5 km² on southwest coast of well-sorted, loose medium to coarse sand arranged in long, linear, subparallel, coastwise ridges. In deepest and most coastal excavations sand overlies cobble gravel of subrounded to rounded stones of porphyritic andesite. Central and eastern (farthest inland) sand ridges enclose B(?) and M(?) tephras variously at depths of 0.4 to 5 m; western (near-coast) ridges are thinner and contain neither B nor M tephra. On map tentatively divided into older, intermediate, and younger phases (units *bedo*, *bedi*, and *bedy* respectively). Near present coasts passes upward into unit *e*

Deposits younger than B tephra (<350 yr B.P.)

- Bln **North Slope lava flow**—Massive porphyritic andesite ranging from light gray (10YR 7/1) to oxidized light reddish brown (5YR 6/3); about 10% plagioclase phenocrysts as long as 4 mm. East side overlain by coarse debris-avalanche levee (unit *83a*) as thick as 15 m
- Bar **Rocky Point debris-avalanche deposit**—Bouldery nonsorted diamict including blocks as large as 5 m. Matrix is sandy gravel of identical angular, finer-grained material. Upper 1 m of a few hummocks shows schlieren of highly altered andesite. Whole deposit is hummocky like nearby Burr Point deposit (unit *83a*). On east and southeast parts hummocks overlain by as much as 30 cm of pyroclastic debris from 1883(?), 1976, and 1986. On north side against beach, some hummocks are overlain by eolian sand capped by the Katmai 1912 ash and at least one older ash
- Bpl **Lithic pyroclastic-flow deposit (or lahar deposit?)**—Bouldery diamict including blocks as large as 2 m. Matrix is sandy gravel of identical but finer-grained angular material. Has leveed, lobate form but heavily vegetated. Overlaps unit *Bawi* downslope
- Bau **Undifferentiated small debris-avalanche deposits**—Bouldery diamict of porphyritic andesite including blocks commonly as large as 6 m, rarely as large as 15 m. Matrix is finer-grained nonsorted diamict of angular clasts. Forms several small lobes on north slope that did not reach below altitude 60 m. Most likely affiliated with events that formed West Island or Rocky Point deposits

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West Island debris-avalanche deposit—Divided into:

- Bawi **Inboard facies**—Bouldery diamict similar to unit *Bawo* but with less local relief, thus much smaller, less distinct, and continuous hummocks. Apparently an irregular, thick veneer over older deposits that had been cut back into coastal sea cliff. Upslope locally underlain by M(?) tephra
- Bawo **Outboard facies**—Bouldery diamict including blocks as large as 4 m. Matrix is sandy gravel of identical finer-grained angular material. Whole deposit is hummocky, hummocks being as high as 30 m and with irregular basal diameter as much as 200 m, but typically 3–15 m high with basal diameters 20–80 m. In places directly overlain by gravelly sand pyroclastic-surge(?) deposit. Southwestern hummocks have flattened tops overlain by patchy poorly sorted sand and capped by lag of 0.5- to 4-m boulders
- MBag **Grouse Point debris-avalanche deposit**—Bouldery diamict of angular blocks ranging to at least as large as 2.5 m. Matrix is sandy gravel of identical but finer-grained angular material, a nonsorted diamict of andesite clasts. Deposit is hummocky with relief as high as 5 m. Overlain by gravelly sand containing angular andesite cobbles and at least 6 fine ash layers including two below Katmai 1912. Could be east arm of Lagoon debris-avalanche deposit (unit *MBal*)

Deposits between M and B tephras (700–400 yr B.P.)

Lithic pyroclastic-flow or lahar? deposit—Divided into:

- MBpli **Inboard facies**—Bouldery diamict of angular andesite distributed as finely lobate and leveed. Consists of angular gray to reddish andesite clasts as large as 3.3 m but mostly <1 m. Capped by pinkish incipient soil, and that discontinuously capped by rare pumiceous B tephra and by Katmai 1912 silt ash. Below altitude 180 m heavily vegetated; about altitude 180 m only sparsely so but more than 1976 and 1964 deposits
- MBplo **Outboard facies**—Cobbly sand diamict as thick as 4.1 m atop sea cliff (now-isolated from the sea) along inner margin of West lagoon. Overlies soil developed on M? tephra and capped by pumiceous B(?) tephra. Upslope becomes intricately lobate and leveed and with many meters of local relief
- MBal **Lagoon debris-avalanche deposit**—Bouldery diamict including blocks as large as 4 m. Matrix is sandy gravel of identical but finer-grained angular material. Whole deposit is hummocky, hummocks having relief as high as 30 m and with irregular basal diameter as much as 200 m, but typically 3–15 m high with basal diameters 20–80 m. Overlain by B tephra
- MBas **Southeast Beach debris-avalanche deposit**—Bouldery diamict exposed in upper part of bluff along Southeast beach. Deposit studded with angular blocks as large as 2.5 m and as large as 6 m as lag on beach and as large as 7 m seaward. Matrix is sandy gravel of similar finer-grained material. Overlain by B tephra; underlain by M and C tephras, which overlie unit *HCpe* that forms most of bluff

- MBlp **Lahar or pyroclastic-flow deposit**—Sandy gravel diamict containing angular lithic andesite clasts rarely as large as 2 m on southeast coast. Associated with unit *MBas* to west. Overlain by B tephra, underlain by M and C tephtras. Apparently similar deposit mapped as unit *MBplo* in Southwest swale
- MBI **Lahar deposit**—Diamict of granular medium sand capping terrace at mouth of West Kamishak Creek. Contains angular andesite clasts as large as 50 cm but no pumice. Overlies M tephra. Similar deposit underlies laharic facies of unit *76p* at mouth of creek. Similar deposit lies in west-southwest swale between high-relief elements of unit *MBp*
- MBp **Pyroclastic-flow deposit**—Massive pebbly sand at least 1.2 m thick containing lithic clasts as large as 20 cm. Overlain by >1 m section of fluvial debris, ash layers, and organic layers capped by B? tephra

Deposits between C and M tephtras (1000–700 yr B.P.)

- CMp **Pyroclastic-flow and -surge deposits**—Along northwest margin of West lagoon, vaguely bedded very fine sand to silt ash at least 30 cm thick (base not exposed); overlain by M(?) tephra. Also west of West Kamishak Creek at coast, small-volume nonoxidized massive gravelly sand (pyroclastic-flow deposit) overlying oxidized unit *HCpw* and sandwiched between tephra layers C and M
- CMI **Lahar deposits**—Cobble gravel to poorly sorted gravelly sand; angular to subangular lithic clasts as large as 25 cm; includes pumice constituent. Underlain by tephra layer C; overlain locally by an ill-defined tephra layer O and by tephra M

Deposits between H and C tephtras (1400–1100 yr B.P.)

- IMan **North Bench diamict**—Bouldery diamict including blocks as large as 4 m. Matrix is sandy gravel of identical but finer-grained angular material. Deposit is only moderately hummocky with local relief as high as 3 m. Cut into gently curving sea cliff as high as 35 m (since half buried), whose development was arrested by emplacement of Grouse Point deposit. This deposit with its high sea cliff is geomorphically similar to several coarse deposits on east and south coasts and must be older than indicated by local stratigraphy. Gullies upslope contain the B tephra at the surface. May predate C tephra (see text)

Southeast lithic pyroclastic-flow (and lahar?) deposit—Divided into:

- HClp **Proximal facies**—contains numerous angular surface boulders in 4–6 m range and a few as large as 9 m. Surface texture coarsely lobate and leveed with local relief as high as 2.5 m. Some smaller blocks prismatically jointed. Directly overlain by C tephra
- HClc **Coastal facies**—Cobble gravel to sandy cobble gravel containing subangular rather than very angular clasts, vaguely stratified and lacking in large boulders, suggestive of lahar deposit. Surface laced with many close-spaced levees. Directly overlain by C tephra and directly underlain by H tephra
- HCpe **Southeast pyroclastic fan**—Massive pumiceous gravelly medium sand (pyroclastic-flow deposit) with interbedded gravelly zones as thick as 31 m. Overlain by C and M tephtras

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- HClw **Southwest lahar deposit**—Cobble to boulder gravel containing angular to subangular clasts of variously gray to reddish porphyritic andesite. In upslope portion boulders commonly as large as 3 m, rarely as large as 9.5 m; in coastal exposures boulders smaller than 0.5 m. Surface of upslope portion embellished by numerous intricately lobate margins downslope from close-spaced levees. Upslope portion very spottily overlain by C and M tephra, coastal portion overlain by pyroclastic-flow deposit unit *HCpw* that is capped by C and M tephra
- HCas **South Point debris-avalanche deposit**—Bouldery diamict of angular porphyritic-andesite fragments. Similar to units *Bar*, *MBag*, and *MBal*, including surface boulders commonly as large as 2 m, many in 4–5 m range, rarely as large as 9 m. Hummocky surface with as much as 10 m of local relief but much subdued by overlying tephra and peat deposits. Overlain only by section containing C and M tephra. Cut back into sea cliff as high as 30 m that projects 600 m seaward as a broad, sharp salient. Buried older sea cliff
- HCal **Long Beach debris-avalanche deposit**—Bouldery diamict of angular fragments dominantly of porphyritic andesite but also containing smaller sandstone clasts. Hummocks as tall as 9 m, andesite boulders rarely as large as 6–9 m. Poorly exposed. In exposures back of Long Beach grades east or is overlain by laharic facies, unit *HClw*
- HCpw **Southwest pyroclastic fan**—Massive pumiceous gravelly medium sand (pyroclastic-flow deposit) as thick as 5 m. About 80 percent of gravel clasts are pumice as large as 10 cm, the rest angular lithic andesite as large as 5 cm. Upper 2 m oxidized reddish. Overlain by C and M tephra; underlain by massive sandy gravel more than 5 m thick, unit *HClu*. Surfaces inland are smooth and free of boulders
- HClA **Lahar and debris-avalanche deposit**—Deposits as thick as 20 m atop landslide block 2.2 km west of South Point. Massive diamicts with angular andesite boulders as large as 4 m (debris-avalanche deposit?) overlie and underlie similar deposits but with smaller and fewer boulders and with vague bedding (apparently lahar deposit). May be arms of units *HCl* and of unit *HCas* or *HCal*. May underlie H tephra as well as C tephra

Deposits between I and H tephra (1700–1400 yr B.P.)

- IHa **Northeast Point debris-avalanche deposit**—Bouldery diamict, coastwise about 3.2 km broad, of angular porphyritic-andesite fragments. Similar to units *MBag*, *MBal*, and *HCas*, including 2–4-m surface boulders, rarely as large as 7 m. In places pods 30 m long and 10 m high consist of nearly monolithologic andesite as close-packed very angular clasts. Hummocky surface with as much as 9 m of local relief but both relief and slopes much subdued by thick overlying tephra and peat deposits. Overlain only by H and younger tephra, underlain by I tephra. Cut back into sea cliff as high as 18 m that projects seaward 400 m as a narrowed salient. Buried older sea cliff
- IHI **Lahar(?) deposit**—Sandy gravel diamict containing angular porphyritic andesite outside (north) of levee delineating north side of main part of Northeast Point diamict (unit *IHa*). Similar sandy gravel underlies H? tephra atop “Eagle bluff” landslide block on south side of island

Deposits between G and I tephra (2100–1800 yr B.P.)

- Glays **Yellow Cliffs and Southeast Point debris-avalanche deposits, composite**—Bouldery diamict of angular porphyritic-andesite fragments. Comprises two stratigraphically superposed similar deposits, the Yellow Cliffs diamict overlain by Southeast Point diamict. Where not buried by unit *IHa*, the hummocky surface of Southeast Point deposit has 5 to 8 m of local relief albeit much subdued by thick capping tephra and peat deposits (thickest in inter-hummock lows). Southeast Point deposit overlain by I and younger tephra. Unlike all other Augustine debris-avalanche deposits, the Yellow Cliffs unit consists largely of andesite clasts that are yellowish and highly altered to clay; its local surface relief seen in sea-cliff section is at least 5 m

Deposits older than G tephra (2200?–2000? yr B.P.)

- G-a **East Point debris-avalanche deposit**—Bouldery diamict of angular porphyritic-andesite fragments, a few prismatically jointed (juvenile). Underlies Yellow Cliffs diamict (lower diamict of unit *GIysa*) and underlies sparsely exposed G tephra. Similar to unit *IHa*, including angular boulders as large as 4–8 m

Domes and lava flows of uncertain late(?) Holocene age

- ds **Pre-1883 summit-dome complex**—Succession of porphyritic-andesite domes forming east crater rim and steep upper east and south outer flanks. Apparently little changed since 1883 eruption. By surface color and apparent overlapping relations divisible into three parts (oldest, 1; youngest 3)

Flank features—Divided into:

- dh **Dome “H”**—Topographic bump on the northwest volcano flank at altitude 910 m consisting of gray (N 5/0) porphyritic andesite containing about 15 percent plagioclase phenocrysts as long as 4 mm
- di **Dome “I”**—Topographic bump on the northwest volcano flank at altitude 1025 m consisting of pinkish gray (7.5R 6/2) porphyritic andesite containing about 15 percent plagioclase phenocrysts as long as 4 mm
- dk **Dome “Kamishak”**—Topographic bump on the south volcano flank at altitude 513 m consisting of light gray (N 7/1 to 5YR 6/1) porphyritic andesite containing about 15 percent plagioclase phenocrysts as long as 3 mm and about 3 percent hornblende phenocrysts as long as 3 mm
- ld **Lava flow**—Inliers on south flank of *in-situ* porphyritic andesite with steep seaward slope: old dome and (or) lava flow nearly buried by younger materials

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DEPOSITS OF LATE PLEISTOCENE TO LATE HOLOCENE AGE

- PHfp **Fall deposits and pyroclastic-flow deposits, undivided**—Interbedded pumiceous pyroclastic-flow deposit, lithic pyroclastic-flow deposit and many beds of loose, sorted pumiceous fall deposits exposed on sides of several south-flank kipukas. Uppermost beds probably correlative with M, C, and older tephra beds of coastal sequences. In places, lowest parts of these sequences overlain by Pleistocene glacial deposits

DEPOSITS OF LATE(?) PLEISTOCENE AGE

- Pg **Glacial deposits**—Sandy gravel or gravel veneer of diverse angular clasts as large as 1.5 m of exotic lithology including black argillite, diorite, granodiorite, granite, gneiss, porphyritic dike rocks, gabbro, greenstone, and banded limestone and chert. Probably discontinuous till; found only on south side of island
- Pog **Outwash gravel**—Waterlaid pumiceous and lithic pebble to granule gravel locally rich in exotic, rounded pebbles. Found only on south side of island. Section contains bed of angular pumice, apparently tephra-fall deposit

Volcanic materials—Divided into:

- Pvr **Rhyolitic pumiceous beds**—Thickly bedded gravelly sand diamict containing angular to rounded pumice clasts (pyroclastic-flow beds), alternating with beds of sorted angular pebble gravel of angular pumice clasts (fall beds). Fall beds contain as much as 40% lithic clasts
- Pvb **Basaltic hyaloclastite**—Poorly bedded sandy pebble gravel containing angular clasts as large as 10 cm, rarely to 20 cm, of scoriaceous olivine basalt. Locally overlain by bedded rhyolitic pumice. Base exposed in one site shows 3 m of fragmental flow deposits containing lithic andesite and pumice clasts (included in this map unit)
- Pl **Block landslide**—Sandstone and shale of Naknek Formation highly jointed and faulted, riddled with open fissures, apparently a displaced block derived upslope from unit *Jnsu*

PRE-AUGUSTINE ROCKS

Rocks of Naknek Formation (Jurassic)—Divided into:

- Jns **Upper sandstone**—Cliff-forming medium to fine thick-bedded yellowish pale-brown sandstone with partings of very fine sandstone to siltstone. Locally ripple marked and containing foreset beds as thick as 1.5 m dipping west or southwest. Rich in marine shells, along with rare flattened logs and stems. Upsection becomes rich in granule to pebble conglomerate containing rounded stones of mixed crystalline rock types.
- Jnsh **Shale**—Dark-gray shale, mostly siltstone with thin interbeds of sandstone. Includes at base lower sandstone of Buffler (1976), cropping out mostly below high-tide line