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NORTHERN BERING SEA, A MODEL FOR DEPOSITIONAL HISTORY OF ARCTIC SHELF PLACERS; ECOLOGICAL IMPACT OF PLACER DEVELOPMENT

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Introduction

The northern Bering Sea (Fig. 1) was chosen for this study because it is a shallow continental shelf area in which submerged beach ridges, stream valleys and glacial moraines occur, and such features have produced over $100 million worth of gold in adjacent onshore regions at Nome, Alaska.

The northern Bering Sea has a relatively protected environment. It is covered by moving ice for about seven months of each year, and wave energy is low. However, bottom currents as strong as 1 knot or more occur along much of the coastline and increase to 2-3 knots near straits. The relatively strong bottom currents have prevented deposition of recent Yukon silts over much of the region (Fig. 1). Consequently, relict sands and gravels that cover much of the sea floor in the Chirikov Basin have not been buried.

Our evaluation is based on more than 700 large samples of surface sediment (Fig. 1) and 50 bore holes that were drilled near Nome by the U.S. Bureau of Mines. All samples were screened to remove the gravel fraction, and silts and clays were washed out. The samples were then panned for heavy metals and the gold content was determined by amalgamation and weighing or by atomic absorption methods (Van Sickle and Laekin, 1968). The tin and other heavy metal content was determined by semiquantitative emission spectrographic analysis of 60 elements.

Potential Offshore Gold Placers

Except for nearshore regions, most of the northern Bering Sea is remote from bedrock sources of gold onshore and insulated by Tertiary sediments from possible bedrock sources below the sea floor. However, land mapping, seismic profiling, and sediment samples show that during times of lowered sea level, glaciers pushed auriferous debris as much as 5 km beyond the present shoreline of Seward Peninsula and also pushed it nearly to the center of Chirikov Basin from the Siberian Peninsula of Chukotka (Fig. 1). Coarse sediment textures, gold content, and presence of washed gravels far from the present shoreline indicate that subsequent transgression and regression of the sea have reworked the exposed glacial drift and left gravel as a thin lag layer overlying the glacial deposits; this veneer is richly auriferous along parts of the southern Seward Peninsula coast. During stillstand beaches developed at about -36, -70 and -80 feet in the Nome region (Fig. 2). Small amounts of gold are found in surface samples of the ancient, submerged beach gravel, and larger concentrations may be present at depth. Streams have dissected the offshore moraines during periods of lowered sea levels; gold is locally concentrated in the resulting alluvium but is generally buried and has not been well sampled by the few scattered drill holes. Since the last rise in sea level, nearshore bottom currents have deposited sand, silt, and clay, generally lacking gold, in the former stream valleys and other topographic depressions; they also have prevented the burial of auriferous relict gravel in the Nome nearshore regions of elevated topography.

Flakes 1 mm in diameter or larger constitute the bulk of the gold in the relict gravel; the distribution of this coarse gold, as well as lateral variations in median gold content of pannable particulate gold in different areas, provide evidence of the location of offshore gold sources. Most gold flakes 1 mm or more in diameter are found (1) in the vicinity of bedrock exposures on the sea floor, (2) near outcrops of mineralized material on land, and (3) in offshore deposits of glacial drift. Small gold particles (about 0.25 mm or less) have been widely dispersed from these source areas by waves and bottom currents, but gold flakes 1 mm or more in diameter have not been transported from the offshore source by marine processes.

The fine-grained bottom sediments of the Chirikov Basin contain small quantities of fine gold. Regional median values of pannable particulate gold amount to a few tenths of a part per billion in most areas in the Chirikov Basin and are higher near source areas; however gold too fine to be recovered in a gold pan also occurs in small quantities throughout the basin.

Statistical tests on the gold content of samples from a small area in the Nome region where relict surface gravels overlie drift suggest that coarse gold flakes (> 1 mm) are randomly distributed, that average tenor is 920 ppb, and that a potentially minable deposit exists. Specific values and locations cannot be discussed for private concessions, but surface gravel samples from one 6-square mile area have an overall average value of $1.48/cu. yd. (920 ppb [1] (Nelson and Hopkins, 1969). The total minable yardage cannot be reliably estimated because average thickness and exact lateral extent of the auriferous, surface gravel layer have not been adequately established by the existing drill holes, and because offshore mining costs are unknown.

Geologic setting and distribution of coarse gold particles elsewhere in the northern Bering Sea indicate that placer deposits probably occur (1) offshore from Nome, in relict gravel veneer of older buried glacial drift and in basal gravel of ancient stream valleys and beaches cutting drift, and (2) on the sea floor in gravels overlying bedrock near Sledge Island. In general, significant concentrations of gold should occur in offshore relict gravels deposited by shoreline or stream processes that rework glacial drift or bedrock that contains coarse gold.

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1. Based on a price of $ 35 per ounce for gold, 10 ppb is equivalent to 1 cent per ton, or 1.6 cents per cubic yard.

Potential Offshore Tin Placers

Potentially economic concentrations of tin have been detected just offshore from the mouth of Cape Creek in the vicinity of Cape Prince of Wales (Fig. 3). However, the significance of this finding is uncertain because of the probability that shoreline processes have reworked old mining tailings. Two anomalously high yet sub-economic concentrations of tin were detected on the north side of Cape Prince of Wales 7-12 miles from the anomaly near Cape Creek. These indicate either an offshore source of cassiterite in the submerged bedrock scarp of Cape Prince of Wales or concentration, by marine processes, of heavy metals in nearshore sediments.

The sedimentary processes in the Cape Prince of Wales region are very favorable for the concentration of heavy metals, particularly cassiterite. Strong currents sweep the fine material from the southern Cape and nearshore regions through the Bering Strait to the northern side. Since cassiterite is very brittle and appears to be readily broken down to fine grain size on the beaches, it may be carried through the Strait and selectively concentrated on the north flanks of Cape Prince of Wales by winnowing action of the currents.

Possible Effects of Offshore Mining on the Environment

The ecological effects of industrial activities are increasingly a matter of public concern. A lack of offshore mining experience in the northern Bering Sea region makes it difficult to appraise all possible consequences. However, several observations suggest that the ecological impact of mechanical reworking by offshore mining would be small and temporary. This is assuming that offshore mining operations would occur on known placers within several kilometers of the south shore of Seward Peninsula. There organisms are adapted to abnormal turbidity or siltation because strong currents carry great quantities of suspended sediment past this coastline (McManus and Smyth, 1970). A large portion of the Yukon River sediment flushes along the nearshore area and the temporary siltation increase by a local mining dredge would be insignificant by comparison.

In addition to the present conditions of extreme siltation, local nearshore marine organisms already are adjusted to physically severe bottom conditions resulting from seasonal development of ice pressure ridges and anchor ice formation. Each winter extensive ice pressure ridges scrape and "bulldoze" the sea floor in nearshore

2) John Burns, written commun., Alaska Fish and Game Dept., Nome 1966

regions of shore-fast ice. Occasionally, severe anchor ice formation destroys sessile benthic fauna to depths of as much as 10 m[2]. The continued presence of a sessile benthic assemblage, however, attests to its adaptability to severe mechanical disruption as well as extreme silting.

Crab and cod are absent in summer and present in winter, showing that nektonic organisms in the Nome region, as elsewhere, adapt to seasonal conditions by migrating. Because of nekton migration habits, commercial, sport, and native subsistence fishing are quite limited in the nearshore regions during summer; this again would help to alleviate physical damage from an offshore placer operation.

An offshore mining operation, although disrupting the shape of the sea floor, would not create a permanent eyesore like those which can occur with land mining operations. Placer operations, fortunately, do not utilize heat or chemical procedures or discharge such effluents with their tailings. Offshore placer mining has the general advantage over land operations of greater dilution of pollutents and the particular advantage of strong currents sweeping past southern Seward Peninsula.

Critical environmental assessment would be necessary for any offshore mining operation, but different faunal and sediment distribution patterns of winter seasons require the most careful evaluation because of lack of study and the potential for the greatest ecological disruption. In contrast, mechanical disturbance by summer mining operations, although causing severe temporary disruption, seems unlikely to permanently disturb the environment of the Nome or of Cape Prince of Wales regions in view of present: (1) seasonal migration habits of the nektonic fauna, (2) large influx of sediment in summer, (3) rapid dispersal of disturbed sediment by nearshore currents, and (4) ability of the fauna to become re-established after destruction by ice scouring and anchor-ice formation.

Conclusions

Most of the Chirikov Basin is remote from onshore bedrock sources of gold and tin; possible bedrock sources below the sea floor are covered by Tertiary sediments. The most promising offshore gold concentrations occur in areas of glacial drift that have been reworked by waves, currents, or streams. The richest deposits are in relict surface sediments where Holocene deposition has been prevented by current action. These gold-rich relict sediments are found mainly on slight topographic highs over glacial drift derived from rich onshore placer deposits. Coarse gold in rich offshore relict sediments is not moved laterally, even by very strong bottom currents; however, during the Pleistocene transgression and regressions of shorelines, longshore drift processes dispersed fine visible and subvisible gold over the entire Chirikov Basin and deposited it in places where it is not in hydraulic equilibrium with present-day bottom currents. Modern bottom currents preserved the relict placers and may be partially responsible for concentration of tin placers with fine grain sizes. Since the nearshore benthic and nektonic organisms are adapted to sediment-laden water, ice scraping, and occasional formation of anchor ice, mining of the nearshore placers along southern Seward Peninsula may not permanently affect the ecology

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"Approved by the Director, U.S. Geological Survey".

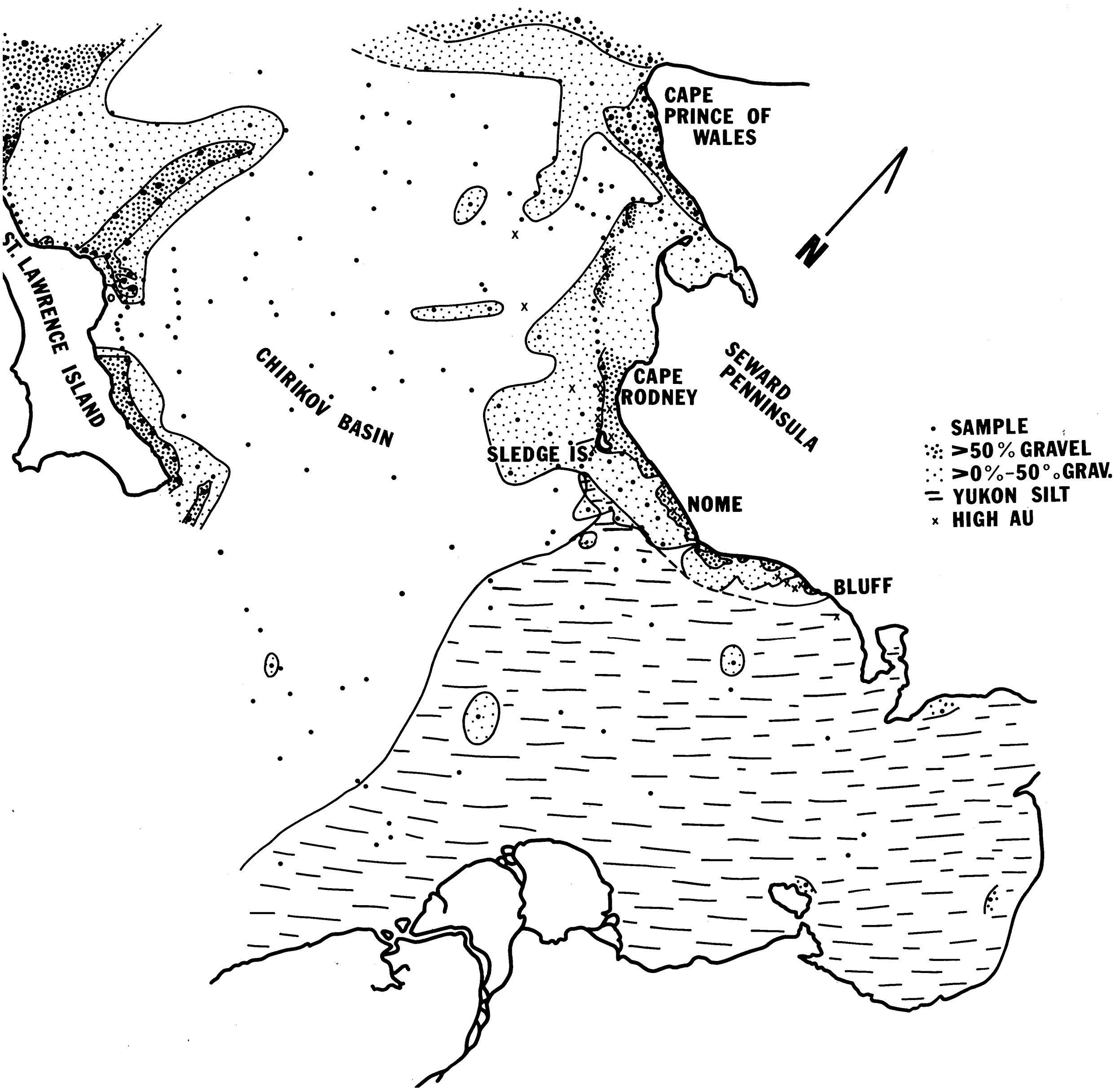

Fig. 1 Distribution of surface sediment types and gold anomalies in northern Bering Sea

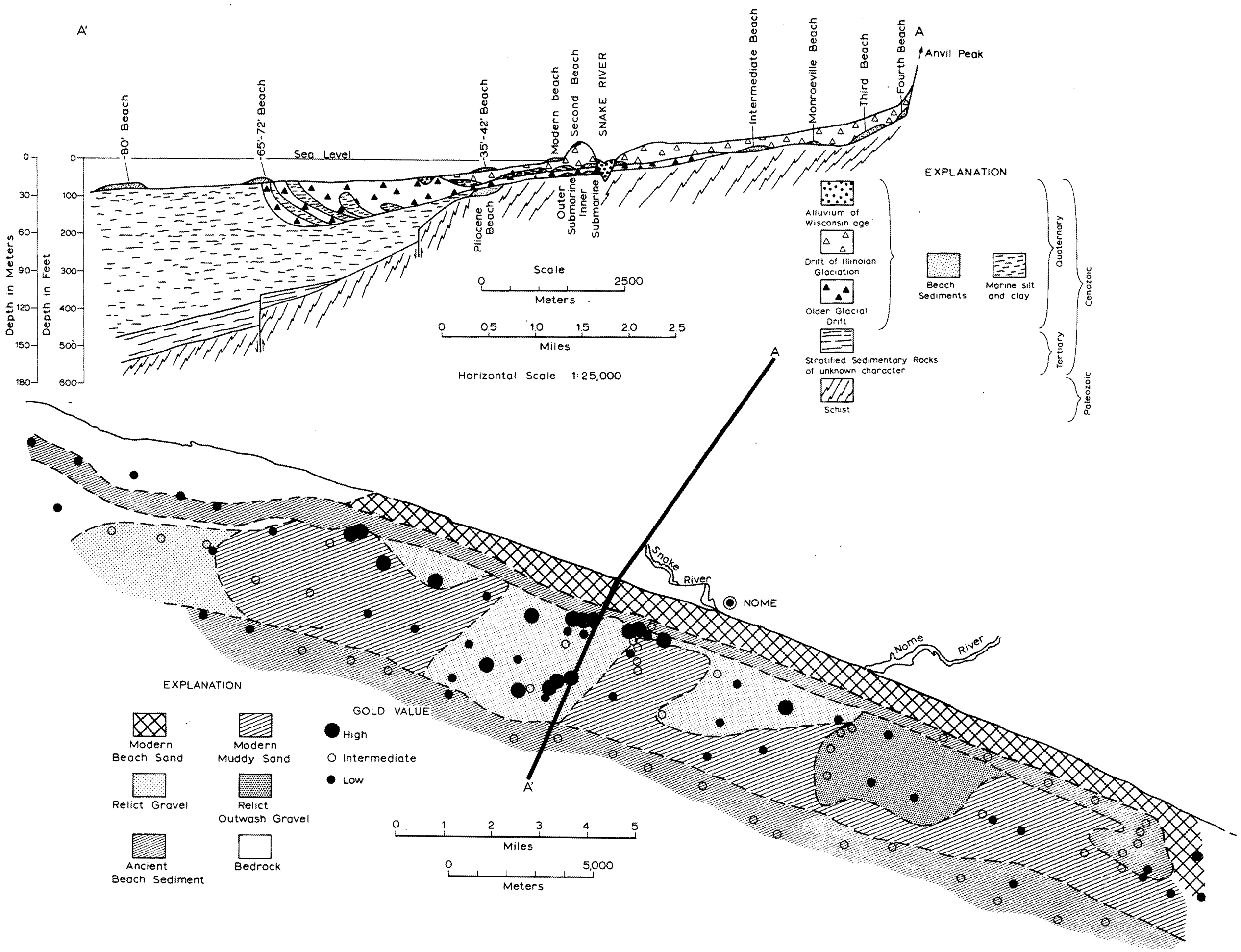

Fig. 2. Geologic cross section and offshore distribution of surface sediments and gold near Nome, Alaska

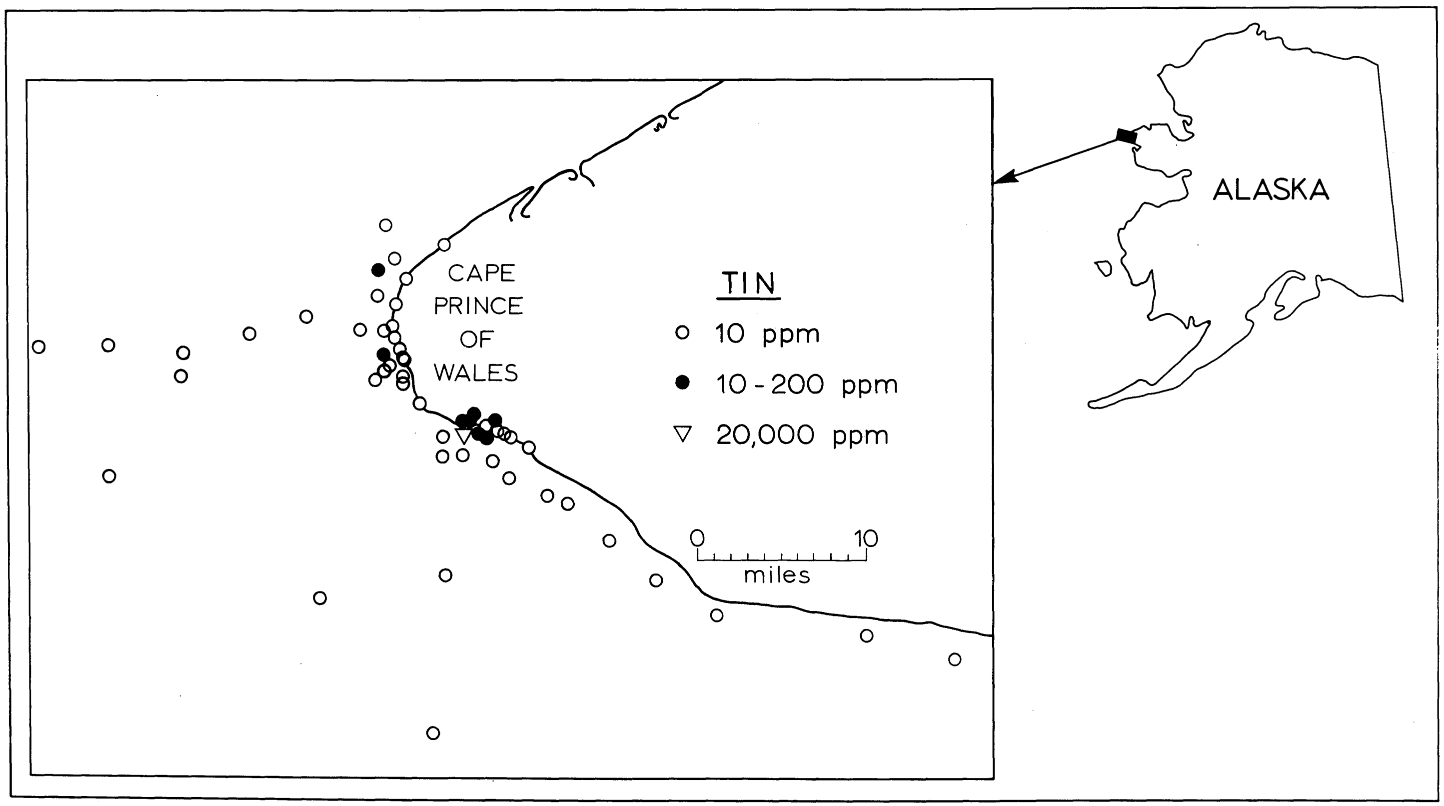

Fig. 3. Tin content of surface sediments near Cape Prince of Wales, Alaska.