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Title: *Air Photo Reconnaissance of Slope Failures in the Presumpscot Formation, Cumberland County, Maine*

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Air Photo Reconnaissance of Slope Failures in the Presumpscot Formation, Cumberland County, Maine

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INTRODUCTION

Earth processes acting on the landslide-prone glaciomarine silty clays (Presumpscot Formation) of southern Maine can cause slope failure. The purpose of this study was to prepare a series of detailed maps showing the locations of all known landslides in the portion of Cumberland County, Maine, that experienced late-glacial marine submergence and thus contain Presumpscot Formation clay deposits. Interpretation of aerial photographs provided the basis for delineating the location of these failures on 1:24,000 U.S. Geological Survey topographic quadrangle maps. The airphotos, supplemented by existing data and some field work, provided an overall view of landslide frequency and distribution in the area seaward of the limit of marine submergence.

Previous studies west of Portland, Maine, along the Presumpscot and Stroudwater Rivers, have shown that landslides in the Presumpscot Formation are more common than historical records would suggest. The study reported on herein, in conjunction with others focusing on the landslide susceptibility of the Presumpscot Formation, is part of an effort by the Maine Geological Survey to understand the nature and extent of the landslide hazard in Maine.

BACKGROUND

Public awareness of Maine's landslide susceptibility was raised as a result of the September, 1983 failure in Gorham, Maine (Novak et al, 1984; Novak, 1987a). Concerns were expressed that more failures might occur in the future as development pressures forced usage of slide-prone areas. Soon after the landslide in Gorham the Maine Geological Survey, with funding support from the Office of Earthquakes, Volcanoes, and Engineering of the U.S. Geological Survey, began a program aimed at increasing understanding of landslide distribution and processes within the state. Efforts concentrated on a statewide inventory of known or suspected landslides; a survey of landslide literature; and mineralogy, pore-water chemistry and engineering studies of the Presumpscot Formation (Novak, 1987b, 1988; Mayer, in press; Devin and Sandford, in press; and Amos and Sandford, 1987). This report continues earlier efforts by focusing on airphoto mapping of suspected landslides.

METHODS

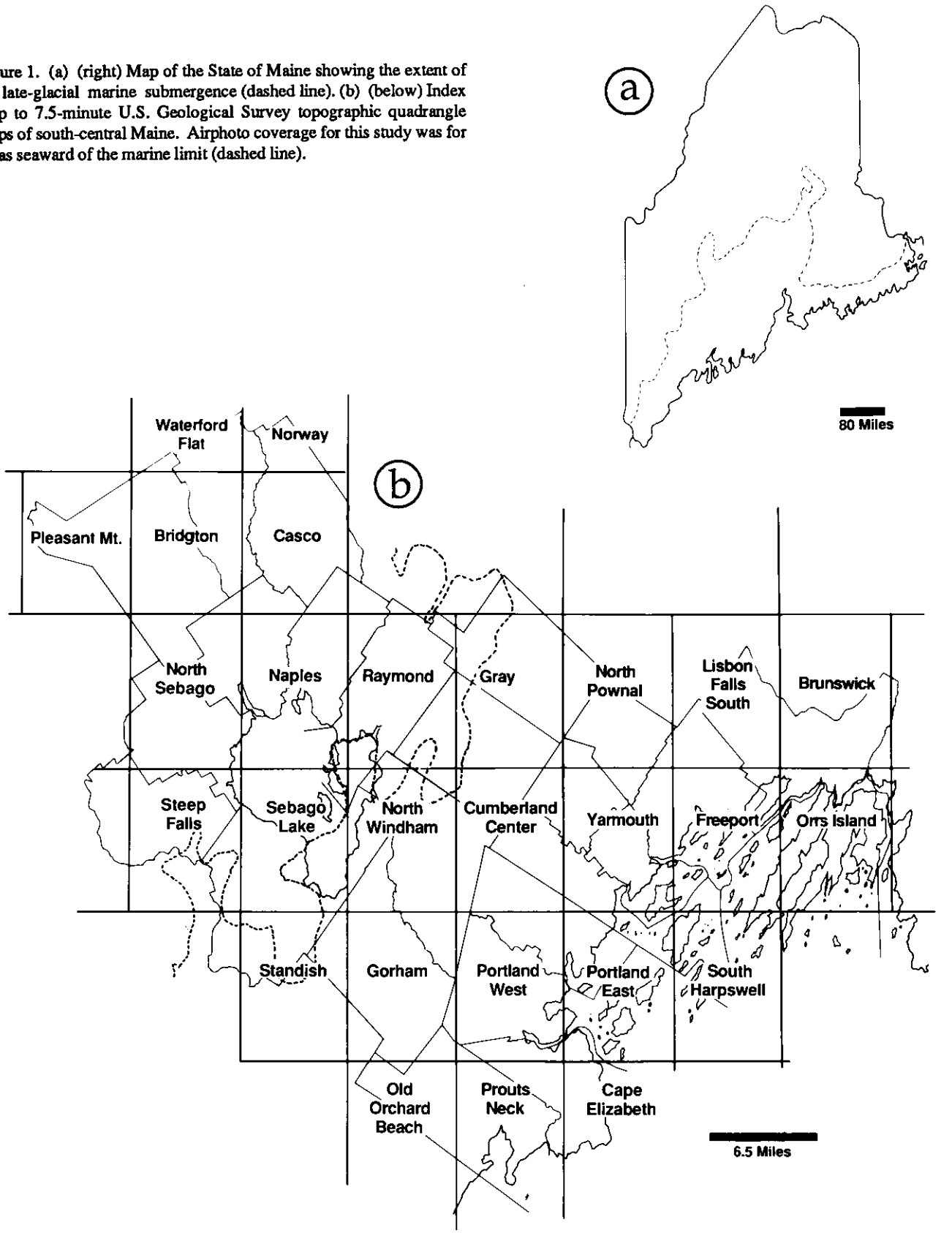
Over 900 aerial photographs from 28 flight lines covering that portion of Cumberland County, Maine, below the marine limit were examined (Fig. 1). The airphotos were taken in 1986 by the Joseph W. Sewall Company of Old Town, Maine, for the Greater Portland Council of Governments and provided stereoscopic coverage of the area at a scale of 1:12,000.

It is generally accepted that "site topography is the first clue to potential instability and the degree to which an area has undergone landslide activity." Aerial photographs provide an overview that can reveal landslides as typical undulating topography or arcuate scarps (Sowers and Royster, 1978). Rib and Liang (1978) listed 13 features discernible on aerial photography that are indicative of landslides or landslide-prone terrain. Of the 13, the following features were most applicable to this study.

1. Land masses undercut by streams;
2. Sharp line or break at the landslide scarp;
3. Unnatural topography, such as a spoon-shaped trough in the terrain;
4. Accumulation of debris in drainage channels or valleys;
5. Seepage zones;
6. Inclined trees.

Known and suspected landslides were plotted on U.S. Geological Survey 7.5-minute topographic maps (see index map of quadrangle names, Fig. 1; and separate maps accompanying this report).

Figure 1. (a) (right) Map of the State of Maine showing the extent of the late-glacial marine submergence (dashed line). (b) (below) Index map to 7.5-minute U.S. Geological Survey topographic quadrangle maps of south-central Maine. Airphoto coverage for this study was for areas seaward of the marine limit (dashed line).



RESULTS

Interpretation of aerial photographs of the area below the glaciomarine limit in Cumberland County, Maine, revealed 180 failures along slopes in rivers, estuaries, and open bays. Photographs covering the Yarmouth 7.5-minute quadrangle revealed 57 landslides. Other failures in the double digits included 37 recorded on the Freeport 7.5-minute quadrangle, 21 on the North Pownal 7.5-minute quadrangle, 19 on the Portland West 7.5-minute quadrangle, and 13 on the Gorham 7.5-minute quadrangle. Table 1 lists the number of landslides found on the airphotos, by quadrangle, in the study area.

The failures occurred in the sensitive silty-clay sediments of the glaciomarine Presumpscot Formation. The dominant types of slope movement appeared to be (using the nomenclature of Varnes (1978)) either earth slumps, earth block slides, or earth lateral spreads. Those slides that were field checked displayed both rotational and translational movement. It is assumed that the majority of the failures identified on the airphotos failed in either of these two ways.

Many small landslides along rivers were frequently associated with meanders having radii of curvature of greater than 200 feet. These meanders were caused by diversion of the channel as a consequence of the failure. Conversely, many failures were the direct result of meander-induced erosion at the base of valley walls. Landslides, therefore, were found on both the concave and convex sides of meanders.

Slope failures adjacent to estuaries and open-bays were identified by head-scarps and bluffs. These failures were associated with bare or marsh grass covered slump-blocks or slide-blocks on tidal mudflats.

Landslide age was determined by the appearance of the associated scarps. The headscarps in failures of more recent vintage were usually arcuate and free of vegetation. Older slides still retained their overall arcuate appearance, but vegetative growth masked the headscarps. Most of the smaller slides (50-300 feet in width parallel to rivers or shores) appear to be of relatively recent vintage. Only a few of the large (500-1200 feet) slidesare known to have occurred in historical times. Only one, the Gorham landslide of 1983, is known to have occurred within the past 100 years. Failures with a linear dimension greater than 1200 feet are presumed to be prehistoric.

TABLE 1. LANDSLIDES BELOW THE MARINE LIMIT IN CUMBERLAND COUNTY, MAINE, BY QUADRANGLE.

Quadrangle Name	Number of Landslides
Cape Elizabeth	0
Cumberland Center	0
Freeport	37
Gorham	13
Gray	0
Lisbon Falls	5
North Pownal	21
Portland East	23
Portland West	19
Prouts Neck	0
Raymond	0
South Harpswell	6
Yarmouth	57

DISCUSSION

Fifty landslides from all over the state were reported in the Inventory and Bibliography of Maine Landslides (Novak, 1987b). Fifteen of those were inventoried for Cumberland County in the 1987 report. The inventory was based upon a questionnaire distributed by the Maine Geological Survey to geologists, soil scientists, site evaluators, civil engineers, and public works directors. At the time it was suspected that many more slope failures existed than were reported because field work and airphoto reconnaissance of the Presumpscot and Stroudwater River Valleys west of Portland revealed many more failures than were recorded in the literature or reported by inventory respondents (Novak, 1987a). This is presumably because slides that occurred within historic time were seldom reported unless they resulted in property damage.

The airphoto study described herein indicates that there are at least 180 failures in Cumberland County in the area of glaciomarine sediments. Therefore, the number of failures identified using aerial photographic methods was more than 10 times the number reported for all of Cumberland County by the inventory questionnaire. This outcome is not surprising because airphoto methods often identify landforms (or, for example, archeologically important sites) that would otherwise not be discernible from ground level. Extrapolation of Cumberland County data to the other nine counties that have glaciomarine sediments subject to failure suggests the possibility of there being many more landslides than was revealed by the inventory questionnaire. The exact nature of county differences will have to await airphoto investigation of these other areas.

Though air photos provide an overall view, they may not provide the data required for detailed landslide studies (Sowers and Royster, 1978). The photo scale, even when magnification or enlargement is used, limits the minimum size of observable features on the pictures. At the photo scale of 1:12,000 (1" = 1000'), a 100 ft. (0.1 in. on the photo) headscarp is barely discernible and may be confused with other possible features. Vegetation frequently masks the features of individual slides or even a slide itself; thus detailed ground surveys must be included as a major tool in landslide investigation (Sowers and Royster, 1978, p.85). In addition to identifying areas that have already failed, air photo investigations "are valuable aids in identifying the (slide) vulnerable locations" (Rib and Liang, 1978, p.55). Landslide studies in Cumberland County, Maine, are approaching the point where they may provide the foundation for the preparation of landslide-hazard maps. Landslide prone areas of Maine are currently undergoing considerable development pressure. Continued investigation of the distribution of landslide

sites and failure prone areas will hopefully provide the tools which could reduce the likelihood of property loss or injury.

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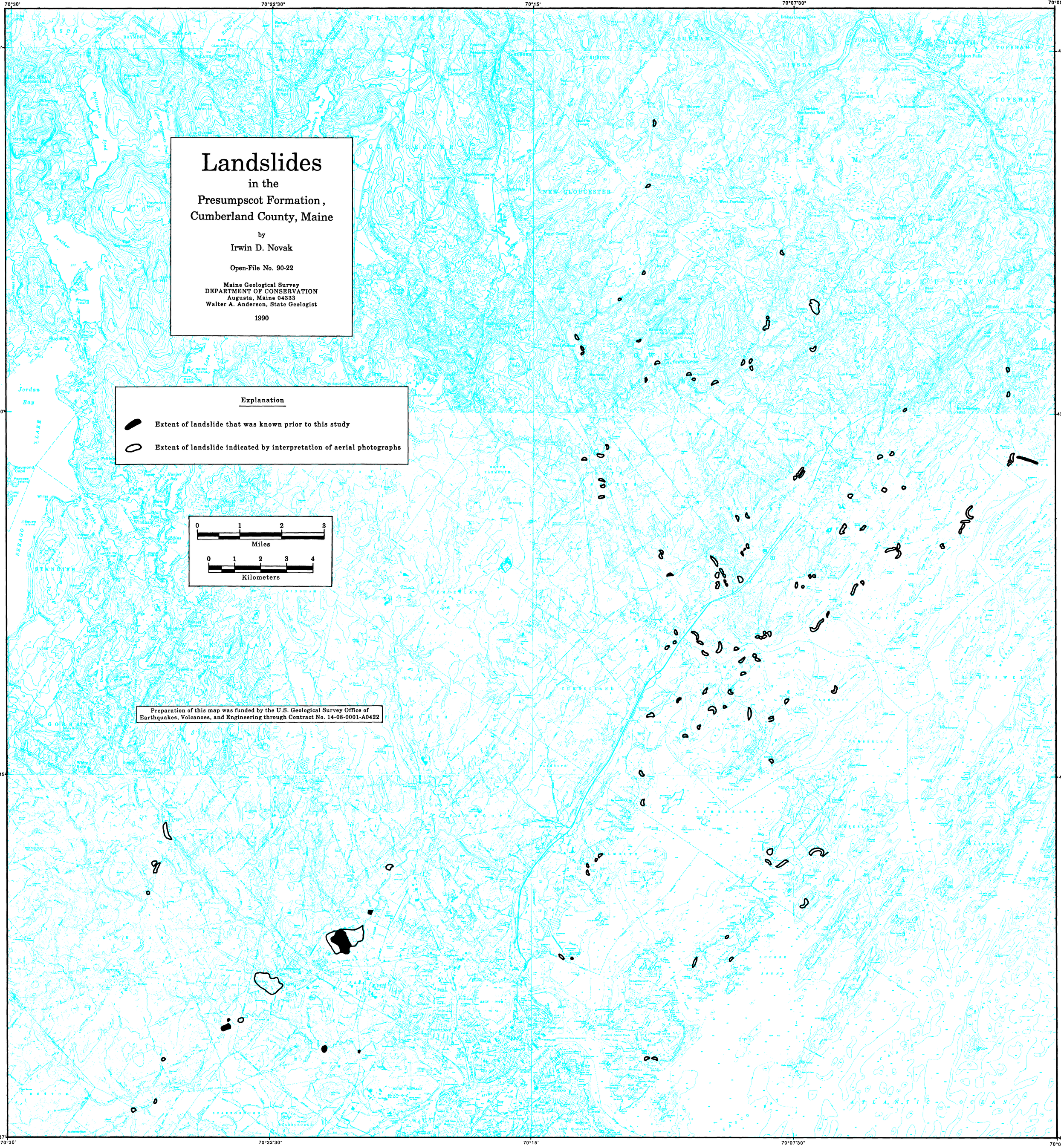

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