GEOLOGICAL MAPPING OF CAMBRIAN AND ORDOVICIAN SEDIMENTARY ROCKS OF THE BELLBURNS (12I/5/6), PORTLAND CREEK (12I/4) AND INDIAN LOOKOUT (12I/3) MAP AREAS, GREAT NORTHERN PENINSULA, NEWFOUNDLAND

by

Ian Knight

ABSTRACT

Lower Paleozoic platformal, flyschoid and allochthonous rocks occur in the map area. Lower Cambrian siliciclastics and carbonates and Middle Cambrian to Middle Ordovician carbonates compose the generally conformable platformal sequence that sits unconformably upon Precambrian granitic basement. Regional subaerial exposure of the platform during sedimentation produced two disconformities at the middle and end of the Lower Ordovician. Paleokarst developed at the surfaces and a network of stratiform and discordant collapse breccias formed at selective lithostratigraphic horizons and close to northeast trending faults.

The platform plunges south beneath Middle Ordovician northeastward and eastward derived sandy flysch. Spectacular limestone breccias derived from destruction of uplifted Middle Ordovician platformal carbonates occur within the flysch. Allochthonous rocks include ribbon limestones and shale and limestone conglomerates and thin bedded fine grained sandstones and shales of unknown age.

The gently to moderately dipping autochthonous strata are transected by numerous long northeast trending and an important group of west trending faults. The Long Range Precambrian inlier is thrust westward over autochthonous strata. A narrow zone of strong deformation and extensive recrystallization of the carbonates occurs in platformal rocks west of the thrust. Inverted bedding, recumbent folds and thrust and reverse faults occur in the zone.

Numerous sphalerite showings occur in dolomites that replace Lower Ordovician limestones in the center of the area. The carbonate hosted Mississippi-valley type deposits form a zinc rich district centered around the Daniels Harbour Zinc Mine.

INTRODUCTION AND GEOLOGICAL SETTING

A large southward-narrowing wedge-shaped area of Cambrian and Ordovician platformal rocks was mapped between River of Ponds and Parsons Pond on the west side of the Great Northern Peninsula (Figure 1). The rocks include gently dipping to strongly deformed strata of the Lower Paleozoic autochthonous Humber Zone, which formed the northern Newfoundland part of the passive margin of Iapetus Ocean. These rocks lie west of uplifted Precambrian basement rocks of the Long Range Mountains and their outcrop narrows to the southwest as they plunge beneath autochthonous Middle Ordovician flyschoid formations and transported Lower Paleozoic deepwater sedimentary rocks of the northern edge of the Humber Arm Allochthon. The Lower Paleozoic autochthon lies unconformably upon Precambrian basement; this contact can be observed only in the northeastern part of the Bellburns map area on and near Blue Mountain.

The autochthonous sequence is essentially a conformable, platformal buildup. However, two intervals of erosion of middle and late Early Ordovician age occur within the carbonate succession. In the Middle Ordovician, the platform collapsed and was blanketed by thick Middle Ordovician flysch derived by erosion of Lower Paleozoic allochthons that were subsequently obducted onto the autochthon during the final phases of the Taconic orogeny. Severe folding and faulting affected the rocks that form the structurally lower parts of the Taconic allochthon. Deformation of the autochthon mainly resulted in many north to northeast and eastward trending faults but, close to the allochthon and near the uplifted Long Range Precambrian inlier, the platformal rocks are much more intensely deformed. The area provides an excellent opportunity to study the faulted contact relationships of the Long Range inlier and the Lower Paleozoic platformal rocks.

Field mapping was done along the Viking Highway, along extensive wood roads, and around many lakes to facilitate access by foot to all but the eastern areas near the Long Range Mountains, where a helicopter was used. Recently regenerated to mature evergreen forests and huge tracts of peat land, particularly in the western and southern parts of the area, characterize the low (60 to 180 m) coastal plain in the area. Only close to the Long Range Mountains, which overlook the plain at an elevation of 360 to 460 m, does topographic relief become rugged. Here, scarp-edged,

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LEGEND

SEDIMENTARY ROCKS OF UNKNOWN AGE, POSSIBLY ALLOCHTHONOUS

Sh - *Green, gray, black shale and mudstone, thin limestone, thin sandstone, red and black chert.*

Cgl - *Limestone conglomerate, thin bedded limestone, shale, minor sandstone.*

AUTOCHTHONOUS ROCKS

MIDDLE ORDOVICIAN

Ss-2 - *Unnamed upper green sandstone, pebbly sandstone, conglomerate, shale.*

Ls-Br - *Unnamed limestone breccia and minor calcarenite.*

Ss-1 - *Unnamed lower green sandstones and interbedded shale, some pebbly sandstone.*

TH Table Head Group - *Limestone, minor dolomitic limestone, dolostone and shale.*

TH-2 - Table Cove and Black Cove Formations
TH-1 - Table Point Formation; THd - dolomitized

LOWER ORDOVICIAN

St. George Group (SG, WB, BH, C, A)

SG - Undivided

A Aguathuna Formation - *Dolostone, dolomitic shale, chert pebble conglomerate and pebbly dolostone.*

C Catoche Formation - *Limestone, C_l, top extensively replaced by diagenetic dolostone C_d.*

BH Boat Harbour Formation - *Limestone, dolomitic limestone, dolostone, diagenetic dolostone, collapse breccias.*

WB Watts Bight Formation - *Diagenetic dolostone.*

MIDDLE TO UPPER CAMBRIAN

Port au Port Group (PP, MP, PJ)

PP Undivided

PJ Petit Jardin Formation - *Dolostone, minor shale and limestone.*

MP March Point Formation - *Dolostone, minor shale, sandstone.*

LOWER CAMBRIAN

Labrador Group (L, B, F, HR)

L Undivided

HB Hawke Bay Formation - *White sandstone, minor shale.*

F Forteau Formation - *Limestone, shale, sandstone.*

B Bradore Formation - *Red and gray sandstone, minor conglomerate.*

PRECAMBRIAN

PE Grenville Basement - *Granite, gneiss.*

SYMBOLS

sp Sphalerite ⚒sp
sp Sphalerite boulders ○sp

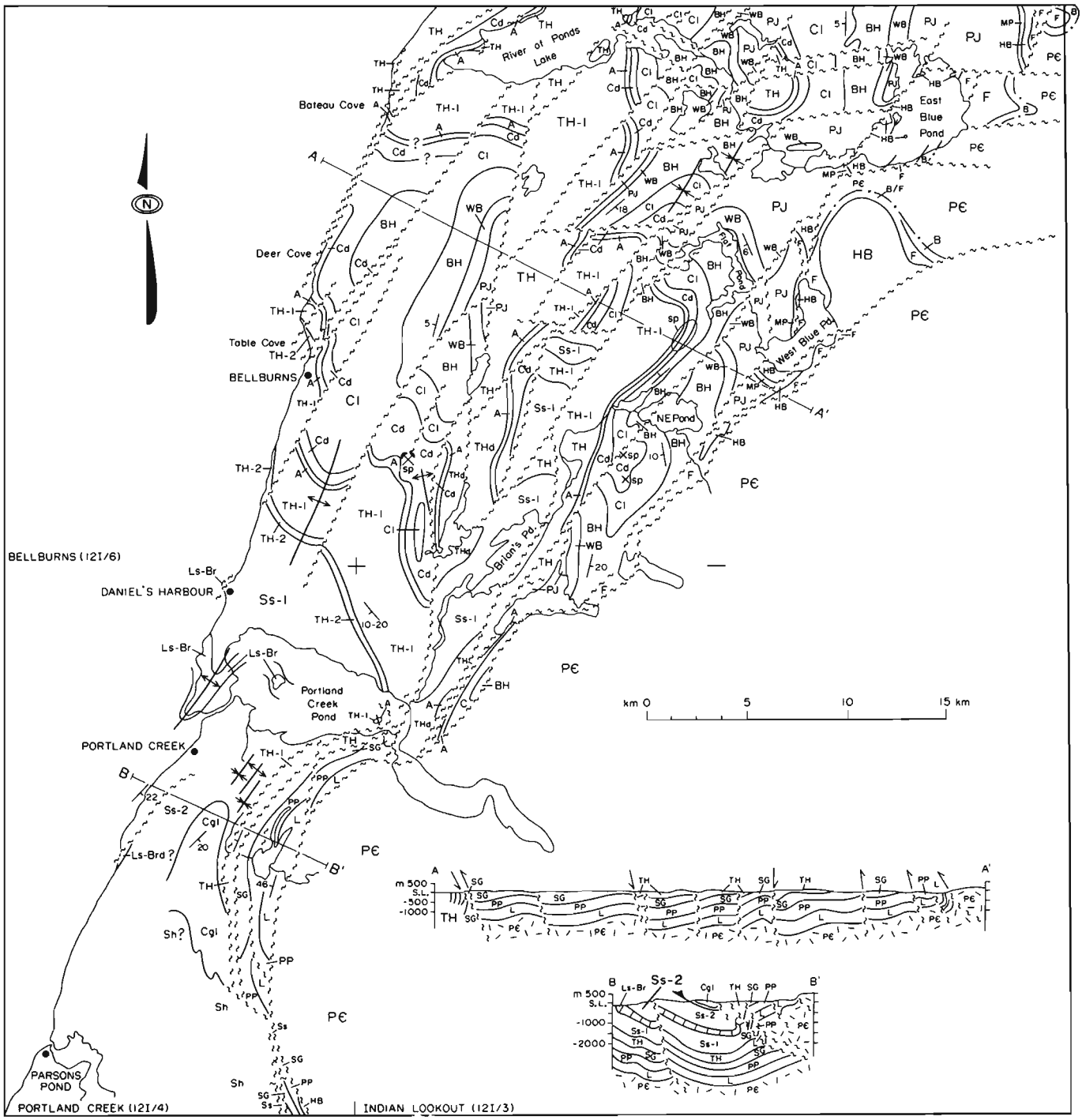

Figure 1: *Sketch map of the geology (in part), of the Bellburns, Indian Lookout and Portland Creek map sheets.*

north trending ridges and lake-filled valleys reflect the 3 km wide, folded and faulted zone of underlying platformal rocks.

The area is well known for the zinc mine at Daniels Harbour. The Mississippi Valley-type sphalerite mineralization in several closely grouped deposits forms the heart of this zinc-rich district.

STRATIGRAPHY

Three geologic terranes occur in the map area; namely, Precambrian basement, autochthonous Lower Paleozoic platformal and basinal sedimentary rocks and allochthonous Lower Paleozoic basinal sedimentary rocks.

Precambrian Basement Rocks: Uplifted Precambrian basement rocks form the Long Range inlier at the eastern edge of the map area. These rocks, mapped only in a reconnaissance fashion for less than 2 km east from their western contact, consist predominantly of massive, slightly foliated, equigranular, fine to coarse grained to megacrystic, pink to red, micaceous granites. Rafts and layers of hornblende-plagioclase and quartz- feldspar-mica gneiss are enclosed within the granites. Chlorite is ubiquitously developed through the granite, suggesting that the basement rocks have undergone greenschist grade metamorphism. Foliations measured in the outcrop generally dip at low to moderate angles to the east.

Lower Paleozoic Platformal Rocks: Lower Paleozoic platformal rocks approximately 1600 m thick in the map area are subdivided according to the nomenclature outlined previously in adjacent map areas by Knight and Boyce (1984). Additional nomenclature follows that of Klappa et al. (1980) for rocks of the Table Head Group. The succession is described in order of the four rock groups that comprise the platformal succession; namely, the Labrador, Port au Port, St. George and Table Head Groups.

Labrador Group (Lower Cambrian): This mixed siliclastic-carbonate succession comprising the Bradore, Forteau and Hawke Bay Formations is exposed only along the eastern edge of the map area. There, it forms either fault-bounded wedges that are steeply dipping to overturned just west of the Long Range boundary fault or flat-lying, rounded to arrowhead-shaped outliers resting unconformably upon Precambrian basement rocks, as on and just north of Blue Mountain.

The succession is best exposed in a steep gulch on the northwest side of Blue Mountain, where it consists of poorly exposed basal pebbly, red arkosic sandstones of the Bradore Formation (1a) overlain by thinly stratified gray, micaceous, sandstones and shales. These are capped by planar laminated and thinly stratified and crossbedded, slightly bioturbated red arkosic sandstones, similar to those described in other Long Range outliers of the Torrent River map area (Knight and Boyce, 1984).

A pink, crystalline dolomite(?) to nodular, shaly fossiliferous gray limestone conformably rests upon the topmost red sandstones of the Bradore Formation. It is correlative with the Devils Cove Member, Forteau Formation, Canada Bay and elsewhere in western Newfoundland (Knight and Saltman, 1980; James and Kobluk, 1978; James and Stevens, 1982). The remaining 110 m of the Forteau Formation (1b) consists of fossiliferous black shales that contain thin bioclastic limestones overlain by crossbedded and stratified, bioclastic and oolitic black limestones. The limestones are interbedded at intervals with cross laminated and laminated, often strongly bioturbated gray siltstones and shales. No evidence of archaeocyathid bioherms has been noted in the map area.

Resting conformably upon the Forteau Formation, are white to pinkish and massive weathering, flinty, white quartz arenites of the Hawke Bay Formation (1c) that form the contour-bedded tops of the outliers. The well sorted, unfossiliferous quartz arenites are crossbedded and commonly ripple marked, but are conspicuously bereft of bioturbation. This is in contrast to several intercalated units, 1-4 m thick, of thinly bedded, planar laminated and cross-laminated, argillaceous and shaly, gray and red quartzose sandstones. These are intensely ploughed by numerous u-shaped and tubular burrows and may contain layers of phosphatic intraclasts. Phosphate crusts on sandstone beds and phosphate, shale and sandstone intraclasts particularly characterize 10 cm thick, cross-laminated and laminated, sandstones that are interbedded with gray shales in a 2 to 3 m thick sequence at the top of the formation.

The characteristics of the Labrador Group support the interpretation of the depositional history of the group in nearby areas as proposed by Knight (in preparation). Braided stream sands deposited on a coastal plain, that lay west of a shallow siliciclastic shoreline, contributed the red and gray sandstones of the Bradore Formation. Widespread transgression established open marine shelf conditions in which accumulated the shallowing upward, low energy shale and high energy, grainy limestone succession of the Forteau Formation. Eastward prograding quartz sands blanketed the carbonate shelf in a complex of tidal sand bodies and related intertidal

facies, as the Hawke Bay Formation completed the succession. Abundant phosphate intraclasts and crusts at the top of the formation suggest exposure of the platform as sedimentation on the Early Cambrian shelf came to an end.

Port au Port Group (Middle to Late Cambrian): A poorly exposed succession of argillaceous dolostones, dolostones, shales and limestones forms the Port au Port Group. The basal March Point Formation (30 m) (2a) rests with sharp conformity upon the Hawke Bay sandstones. This formation consists of basal dark gray shales overlain by yellow weathering, bioturbated and vuggy, thinly stratified, dark gray argillaceous dolostones. Green, gray and reddish shales, yellow weathering, pale gray dolostones, and gray to blue-gray limestones comprise the overlying Petit Jardin Formation (2b). The shales are mostly low in the formation, intercalated with dolostones that exhibit cryptalgal structures and many other features of intertidal and supratidal carbonate flat deposition. Limestones and dolostones are important in a middle member that contains stromatolites, channel-bound and sheeted intraformational floatstones and rudstones, oolitic grainstones, burrowed, thinly bedded and parted limestones and muddy dolomitic carbonates as well as mudcracked horizons. Trilobites recovered from the member in two localities along the west shore and 1.4 km west of Western Blue Pond (known locally as John William's Bluey) include *Arapahoia* sp., *Coosella* sp. cf. *C. helena* Lochman, *Terranovella* sp. cf. *T. obscura* Lochman and *Welleraspis* sp.; they are indicative of the Dresbachian *Crepicephalus-Cedaria* zones which suggests the unit spans the early Late Cambrian (Boyce, this volume).

Buff weathering, thickly bedded, cherty dolostones form most of the upper half of the formation. Burrowed and stromatolitic beds alternate with wavy laminated and thinly bedded microcrystalline dolostones.

The rocks of the Port au Port Group accumulated within shallow subtidal to supratidal carbonate settings. Tidal flats accumulating cryptalgal laminites and mudrocks were established as deposition of the Petit Jardin Formation succeeded the shallow subtidal muds that formed much of the March Point Formation. Higher energy stromatolite buildups, fringed by oolite bodies, and tidal flat deposits crossed by conglomerate-filled tidal channels typify the middle of the formation. More open shelf conditions then produced repeated shoaling upward peritidal sequences, suggesting repeated migration of shallow shoreline conditions as mudflats or mudflat islands prograded seaward over subtidal or lagoonal muds.

St. George Group: The Lower Ordovician St. George Group is widely developed in the central, western and southern parts of the map area. It has been subdivided into four formations outlined previously by Knight and Boyce (1984) and Knight (in preparation) in the Port Saunders area. Lithologically, the basal Watts Bight Formation (3a) is composed of black, fine to medium crystalline diagenetic dolostones exhibiting extensive burrow-mottling of thinly stratified carbonates and lesser cryptalgal mounds; it remains consistent as elsewhere on the Northern Peninsula. It is best exposed around the western part of Eastern Blue Pond (locally called Western Bluey) and near Flat Pond. The overlying Boat Harbour Formation (3b) is not well exposed; it consists of a complex array of interbedded limestones, dolostones, shaly limestones, and diagenetic dolostones. Features of shallow peritidal deposition such as fossiliferous, bioturbated mudrocks, associated stromatolites, flaser bedded and laminated, locally mudcracked, dolomitic limestones were noted in better outcrops.

Highlighting the 1984 mapping in this formation, however, was the discovery of several exposures of the Boat Harbour "pebble bed" and exposure surface along the coast and along a woods road near Bateau Barrens. This interval, which occurs less than 30 m from the top of the formation where it is overlain by cyclically developed grainy and muddy limestones, is expressed slightly differently in the various localities. However, it is always typified by the presence of abundant chert that fulfills a replacing and cementing role within carbonates below the solution surface and is reworked as pebbles in the overlying beds. In the roadside outcrop, the pebbles are scattered in a 60 cm thick conglomerate also containing dolostone and limestone pebbles. In exposures along the shore at Bateau Barrens, chert pebbles are concentrated in the overlying bed and in pockets and fissures along the irregular exposure surface. The chert is typically oolitic, porcelaneous or white megaquartz. Silicified fossil fragments occur in the roadside outcrop within the conglomerate.

Dolomitization of underlying strata also occurs up to a metre thick in the roadside exposure where there are no later dolomite overprints. In the coastal sections, however, dolomitization is considerably thicker, but this is likely related to dolomitization within a complex fault zone that follows the coast from Bateau Barrens south to Deer and Freshwater Coves. There is no relief or evidence of solution in the roadside outcrops, but relief of tens of centimetres occurs in the coastal sections. Also present in the coastal exposures are narrow branching

hardrock fissures penetrating a few metres below the exposure surface as well as locally developed pockets of solution collapse breccias. Both are filled by a microcrystalline, vitreous black dolomite matrix or cement. Metre thick, concordant, stratabound breccias composed of blocky, dolostone fragments up to 20 cm in size and set in a black siliceous dolostone and small rock particle matrix also occur in the same coastal fault zone at the southern end of Bateau Barrens. This breccia rests upon black Watts Bight dolostones and is comparable to other similar breccias that occur in the same stratigraphic interval elsewhere on the Northern Peninsula (Knight, 1978, 1980, in preparation; Knight and Boyce, 1984).

The overlying Catoche Formation (4c) is a succession of well bedded, bioturbated and fossiliferous, gray limestones which are replaced extensively by secondary dolostones towards the top of the formation. The limestones consist mostly of wackestones and packstones that are argillaceous and unevenly thinly stratified; lenses of intraclastic and bioclastic mudstones and planar stratified and rippled marked grainstones also occur. Boundstone mounds occur towards the base of the formation. The secondary dolostones are gray to black, massive, vuggy, and fine to medium crystalline. Open spaces filled by white baroque dolomite occur in selected beds known as pseudobreccia. Limestones are interbedded with and pass laterally into the dolostones towards the top of the formation.

Buff to yellow weathering, microcrystalline, light to dark gray, dolostones and green dolomitic shales of the Aguathuna Formation (4d), form the top of the St. George Group. Lamination, cross-lamination, small tepee structures, intraformational breccias, and mudcracks typify the dololaminites that intercalate with burrow-mottled, and thinly bedded dolostones, and rarely stromatolitic dolostones. Sand and pebbles composed of chert and dolostone lithoclasts also occur in the upper 12 m of the formation where they form layers, a few centimetres thick, in planar laminated dolostone towards the base of shallowing-upward cycles. A number of crudely stratified beds, 40 cm to 3 m thick of chert-dolostone pebble conglomerate, again in the upper 12 m of the formation, occur on the north shore of River of Ponds Lake, the eastern island of Portland Creek Pond and in a fault-bounded wedge along the shore at Table Cove, Bellburns. Silicification, fracturing, post-depositional brecciation and irregular bedding surfaces occur near and below the chert pebble interval in the formation.

There is a major thickness difference of 45 m between sections in the Aguathuna Formation on the northwest (15 m) and northeast (60 m) shore of River of Ponds Lake. This suggests that major faults that transect the lake (Torrent River Fault) have either juxtaposed two different paleogeographical settings or were active during deposition of the formation. At the base of the thinner section, Aguathuna dolostones rest upon a very irregular surface with relief up to 40 cm sculptured in diagenetic dolostones of the Catoche Formation. Silicification and fracturing is common below the surface; depressions at the surface and cavities and fissures below are filled by Aguathuna dolostones and chert detritus.

A coherent part of the Aguathuna Formation are matrix breccia bodies such as described by Lane (1984). The largest exposed rock body at Mine Lake is several hundreds of metres across and contains variable bedding punctuated by zones of mostly dolostone rubble. However, a breccia zone composed of color banded, laminated and thin bedded, black and light gray limestone occurs in the centre of the breccia body that cuts down into the underlying Catoche dolostones and limestones.

Numerous oligo- and polymictic matrix breccia bodies lie along the trace of the Bateau Cove fault zone where it cuts dolomites of the middle of the St. George Group. Abundant spar breccias also occur individually, and overlying and peripheral to matrix breccias. Matrix breccias are both concordant and discordant to bedding. Preliminary studies suggest some of these breccias post-date deposition of the Catoche Formation, while others have been linked to events affecting the older Boat Harbour Formation. Similar breccias have been noted in the Aguathuna Formation west of Eastern Blue Pond.

The buildup of the Early Ordovician platform was accomplished by deposition of generally monotonous subtidal limestone and repeated sequences of peritidal carbonate in two megacycles of transgression and regression. Both Tremadocian (Watts Bight - Boat Harbour Formations) and Arenigian (Catoche - Aguathuna Formation) megacycles culminated in subaerial exposure of the platform which was accompanied by widespread diagenesis, solution and development of a karst cavern system. Areal development of the subterranean cavern systems, now filled by collapse breccias, was controlled by lithostratigraphy and structure. Widespread stratabound collapse brecias are consistently located in basal dolostones of the Boat Harbour Formation immediately above the Watts Bight Formation. The cavern system related to the late Arenig disconformity however, was partly controlled by northeast trending faults and fractures that also influenced the thickness of the

Aguathuna Formation. They also formed the channel ways for deep penetration of solutions through the platform (Knight and Boyce, 1984).

Table Head Group (Middle Ordovician): The Middle Ordovician Table Head Group was defined by Klappa et al. (1979) as consisting of the Table Point, Table Cove, Black Cove and Cape Cormorant Formations.

The Table Point Formation is well known as a highly fossiliferous, well bedded, blue gray to gray, subtidal limestone. This year's mapping has, however, continued to highlight the formation's diversity. The formation commences with a basal cyclic member of bioclastic and intraclastic grainy mudrocks intercalated with laminated, frequently mudcracked, dolomitic lime mudstones or dolostones. This is overlain by a light gray weathering, fine grained, fenestral limestone. The fenestral limestone contains cement-filled skeletal porosity after gastropods and cephalopods as well as tubular and laminar fenestra and "stromataoids" voids, the latter filled by geopetal muds and calcite cements. Although this member is readily distinguished over wide areas of the map area where it can reach 30 m thickness, it is not present at Table Point and in the northeast of the map area where dark gray, mottled wackestones dominate the section. This suggests that there are rapid lateral facies changes; similar conclusions have been reached based on the study of drill logs in the Bellburns map area (Lane, personal communication, 1984).

Fossiliferous and bioturbated subtidal, argilliaceous dark gray limestones overlie the fenestral carbonates. Slump breccias and folds deform the subtidal limestones 3 m below a succession, 23 m thick, of interbedded burrowed, bioclastic wackestones and scour-based, cross laminated grainstones. Some small boundstone mounds also occur and the wackestones and grainstones intercalate upwards with dololaminites. The dololaminites exhibit lamination, cross bedding, mudcracks and fissure cracks, scour-and-fill structures, and pockets of intraformational breccia typical of intertidal settings. A succession of similar lithologies, 19 m thick, occurs in the middle of a westward younging, partly inverted sequence of Table Point Formation west of the Bateau Cove Fault, south of Bateau Cove. The remaining 200 + m of the formation consists of highly fossiliferous, bioturbated, argillaceous limestones that contain abundant large cephalopods, gastropods, sponges, bryozoa, ostracods, trilobites and brachiopods. Nodular to planar, thin bedded, argillaceous, lime mudstones with thin gray shale interbeds characterize the conformably overlying Table Cove Formation. The formation is famous for its Toquima - Table Head trilobite fauna (Ross and Ingham, 1970). Many beds in this formation are deformed by synsedimentary slump folds, thrust faults and rotational slides.

The Table Cove Formation is gradationally overlain by 17 to 27 m of black shales of the Black Cove Formation. A few discontinuous fine limestone beds occur at the base. The top of the formation is badly sheared at Table Cove where it is almost 10 m thinner than at a shoreline section opposite the Daniels Harbour mine road.

Limestone conglomerates intercalated with shales, limestones and sandstones, defined as the Cape Cormorant Formation by Klappa et al. (1980), do not occur in the map area. Limestone breccias occurring at Daniels Harbour, Cliffy Point and Eastern Head and the western island of Portland Creek Pond are believed to lie within a succession of green sandy flysch and are not included in the Table Head Group.

Lithofacies that comprise the Table Head Group were laid down in shallow peritidal to open shelf environments during the deposition of the Table Point Formation. Cyclical peritidal shoaling upward sequences of the basal member of the formation appear to be superceded by shallow water light-coloured, fenestral limestones. These accumulated possibly as dominantly intertidal carbonate mud mounds rich in fenestra and accreting adjacent to areas of shallow subtidal carbonate mud. Shallow sandy to muddy tidal flat carbonates that overlie these deposits were then blanketed by widespread subtidal shelf limestones that hosted a rich shelly fauna. Continued sea level rise drowned the platform margin leading to deposition of slope deposits of the Table Cove Formation and basinal shales of the Black Cove Formation.

Autochthonous Middle Ordovician siliciclastic rocks and limestone breccias: Green sandstones interbedded with black shales form a succession of turbidite sands of great but unknown thickness. The succession is essentially composed of metre-thick sequences of thick bedded sandstones, pebbly sandstones and conglomerates, regularly intercalated sandstones and shales, shales with thin sandstones and siltstones and rare shale-sandstone mixtites. Sandwiched in the middle of the formation is a remarkable sequence of limestone breccia composed of rubble and blocks of Table Head limestone mixed with large ripups of shale and green sandstone. Towards the top and overlying the breccias are some calcarenites composed of rounded limestone sand and granules. No contacts between the green sandstones and limestone breccias are exposed but, 1) the presence of sandstone lithoclasts, 2) the consistent structural position, and 3) the lack of evidence for

faults that might have uplifted and tectonically disrupted Table Head Group, support the interpretation that the breccias lie stratigraphically within the flysch and not at the base. Dolomitized limestone breccias and limestone sandstones that form The Arches south of Portland Creek, may be equivalent to the breccias, later uplifted by a northeast trending fault. If this interpretation is true, then the sandstones and conglomerates forming Portland Hill possibly belong to the uplifted sequence and repeat rocks that occur near and south of Portland Creek.

The green sandstones display grading, massive, laminated and cross-laminated intervals typical of Bouma sequences, convolute bedding, vein networks of pillar structures, shale ripups, allochthonous shelly fossils, and flute and load casted bases. Many of the thicker beds contain pebbles of sandstone, shale, quartz, chert, argillite, light gray to white limestone, and are crossbedded. Conglomerates form a major part of the succession on top of Portland Head. They include pebbles up to 10 cm in size of massive to laminated, sometimes dolomitic, muddy, pale gray, limestone, some with quartz sand laminae, crinoidal grainstone, yellow weathering dolostone, rare black and red chert, green sandstone, and larger intraclasts of intraformationally derived conglomerate. The conglomerates form lenses and beds with sandstone matrices within dominantly green sandstones that are planar laminated or are affected by a gently eastward dipping foliation.

A mixtite composed of sandstone and shale intraclasts in a shale-sand matrix occurs towards the top of the coastal section, 2 km north of the Arches. The shale dominated sequences consist of finely laminated mudrocks intercalated with 1 to rarely 10 cm laminated and cross-laminated siltstone and sandstone beds.

Cross-lamination and crossbeds in the lower sandstones at Table Point suggest a prevailing southward direction of sediment transport. Crossbeds in sandstones near Portland Creek indicate a southwestward to westward paleocurrent direction.

The limestone breccia member of the formation is of unknown thickness although it is probably tens of metres thick. It consists of indistinct, roughly bedded, centimetre sized rubble enclosing blocks that may approach the dimensions of a small house. The lithoclasts in the breccia include limestones of Table Point and Table Cove Formation type as well as black and green-gray shales and green sandstones comparable to the Black Cove Formation and overlying sandstones. Exotic clasts include white fenestral laminated limestones with early geopetal fills and cements, bioclastic limestones and gray and white mottled boundstones. Larger blocks exhibit partial brecciation and buckling. Although most of the breccias lack significant mud matrix, one bed, several metres thick on the western island of Portland Creek Pond, contains limestone clasts floating in a shale matrix. At the top of the unit, in Portland Cove, the breccias are overlain by granulose to fine grained calcarenites composed of rounded gray limestone sand. They are well bedded, graded, crossbedded and internally convoluted. Channels within the breccias north of Eastern Head, are also filled with similar calcarenites that are partly eroded by overlying breccia.

The unnamed Middle Ordovician sandstones and limestone breccias are generally believed to have accumulated in a foreland basin following collapse of the Lower Paleozoic platform and east of advancing Taconic allochthons. The green sandy flysch, exhibiting sand and shale dominated sequences and varieties of turbidites and grainflows, probably formed upon deepwater fans. The lower sandstones and shales derived from the north, blanketed the collapsed carbonate platform. However, tectonic activity within the basin uplifted both sands and parts of the underlying platform which then disintegrated by mass wastage and possibly tectonic disturbance. Megabreccias accumulated in local areas of the basin superceded by finer limestone sand deposits as the uplifted platform highs were reduced in size and/or blanketed by the younger sequence of easterly derived sandy flysch.

Autochthonous or allochthonous sediments of unknown age or affinity: Limestone conglomerates, thin bedded limestones and shales with minor sandstones form an unnamed rock unit (map unit Cgl) on the ridge east of Portland Hill. The unit is at least structurally overlying the green sandstone of Portland Hill, but no contact was observed to prove stratigraphic continuity. A leafy, gently eastward dipping lamination occurs in the last observed outcrop of rotted green sandstone before the limestone conglomerate is encountered. This fabric may have been structurally produced however, had the limestone conglomerate been thrust over the sandstone. The limestone conglomerate unit has been mapped south of Five Mile Road. The succession is dominated by beds up to 4 m thick of pale gray, pebble- to matrix-supported limestone conglomerate composed of well sorted, rounded tabular limestone lithoclasts. The lithoclasts range up to 10 cm in size and include laminated and thin bedded lime mudstones and lesser oolitic and crinoidal grainstones. Some large limestone conglomerate intraclasts also occur. The conglomerates are intercalated with 2 to 10 m sequences

of shale and thin sandstones or laminated thin limestone beds intercalated with black shales, thin bioclastic limestones composed of crinoidal debris and 10 cm beds of calcareous siltstone and sandstone. Rare beds of sandstone which contain limestone intraclasts at the base, and grade up into thin planar stratification also occur in the thin bedded sequences. The unit resembles parts of the Cow Head Group. The presence of oolitic grainstones may suggest a Cambrian age since oolitic carbonates of platformal origin in western Newfoundland mostly occur in the rocks of Cambrian age.

The second sedimentary package of unknown affinity was mapped only in the southeastern part of the Portland Creek map sheet, north of Parsons Pond. It consists of a tightly folded sequence of black, gray, khaki and green colored shales. Interbedded with the shales are nodular, laminated and massive, thinly bedded fine grained, gray limestones, and beds of laminated and cross-laminated, green-gray to buff calcareous siltstones and very fine grained micaceous sandstones. Sedimentary rocks exposed in rare outcrops within the large bogs and along some streams north of the centre of Parsons Pond include bedded gray and red cherts, green and red siltstones and mudstones as well as laminated, very fine grained sandstones. These fine grained sedimentary rocks which appear to structurally overlie unit Cgl are probably part of the Humber Arm Allochthon.

STRUCTURE

The map area like those to the north (Knight and Boyce, 1984), is dominated by a system of long, branching and anastomosing, curvilinear, high angle, north to northeast trending faults. These faults displace units vertically up to hundreds of metres and some are known to have strike-slip motion. Minor open to tight folds that parallel and trend oblique to faults have variable plunges. Locally steepened bedding and intense fracturing also characterize the fault zones.

On the Bellburns map area, particularly near and west of Eastern Blue Pond, a number of east-west faults that are generally downthrown to the northeast, cross-cut the stratigraphy and the northeast faults. In some instances, the latter offset, or terminate, against the west trending faults. An attractive structural interpretation of the area at the north end of Bateau Barrens, which is an alternative to that shown in figure 1, involves downthrowing north dipping Table Head rocks on the north side of west trending faults, against west dipping St. George Group.

Close to the Long Range Precambrian inlier near Western Blue Pond, bedding steepens and overturns in incompetent rocks such as the Forteau Formation and décollement occurs between the Forteau and the overlying Hawke Bay Formation. The Long Range western boundary fault has a sinuous to arcuate northeast trend from Parsons Pond north to Blue Mountain where the fault swings off almost eastward into the Precambrian inlier. This plus the presence of foliation and fracturing in chloritized granite and adjacent platformal rocks within a metre of the sharp fault plane suggests the fault is a thrust dipping at between 45 and 50° to the east. This conclusion is strengthened as the fault is traced south through the Indian Lookout and Portland Creek map sheets where intensity of deformation increases. Here inverted bedding, recumbent folds, eastward dipping reverse and thrust faults associated locally with recumbent west facing minor folds occur in autochthonous rocks in a zone up to 3 km wide within the adjacent platform. Older rock units override younger units westward in this zone. Caution is required in mapping the carbonates of this area, however, because most stratigraphic units have been recrystallized to a uniform fine, equigranular, vuggy, off-gray dolostone.

West of the 3 km zone of faulted platform, deformation of unnamed Middle Ordovician sandy and shaly flysch, is restricted to southeastward dipping monoclinal sequences. However, open, asymmetrical, southwest plunging folds with vertical to eastward dipping axial planes also affect the flysch along Western Feeder Brook and in Table Cove. A single cleavage occurs in interbedded shale beds.

Limestone conglomerates and thin bedded shales and limestones of unknown age structurally overlie the sandstones in a moderately dipping (12-29°) monoclinal southeastward filled sequence. However, allochthonous(?) fine siliciclastic rocks (Unit Cgl) in the southeast of the map area north of Parsons Pond are complexly deformed into a multitude of isoclinal to slightly recumbent folds that trend about 165°, and plunge gently (5 to 8°) to steeply (up to 75°) to the south. The folds which have a metre to decametre spacing, face westward with a well developed eastward dipping axial planar cleavage. Only one phase of deformation appears to have affected these rocks.

ECONOMIC GEOLOGY

The map area contains carbonate hosted Mississippi Valley-type sphalerite-rich district centred northeast of Daniels Harbour. The Daniels Harbour zinc mine, opened in 1975, recovers ore from several narrow, ribbon-like sphalerite lenses that occur in secondary dolostones that replace Catoche

limestones. The mineralization occurs adjacent to collapse breccia bodies associated with a regional late Arenigian disconformity near the top of the St. George Group. Description of host rocks and mineralization is given by Collins and Smith (1975), Lane (1984) and Crossley and Lane (1984). Sphalerite mineralization is also known in the area northeast and east of the mine and includes showings and prospects, such as the Trapper, in rocks of similar type and stratigraphic position.

Outside the district, mineralization is sparse. Some sphalerite crystals have been found in dolomite-cemented vugs along the shore near Deer Cove; black diagenetic dolomites of the Watts Bight Formation from a ridge 5 km west of Flat Pond responded to the application of a zinc reactive solution. However, no visible mineralization was seen.

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