DOE/ER/13747--11

DE92 011128

Depositional and Diagenetic History of the Edgecliff Reefs (Middle Devonian Onondaga Formation of New York and Ontario)

Dr. Thomas H. Wolosz, Center for Earth & Environmental Science, SUNY College at Plattsburgh, Plattsburgh, N.Y. 12901.

Final Report.

DE-FG02-87ER13747.A000

The study of the depositional history of the Edgecliff reefs is complete. Major results include:

A) Identification of the Edgecliff and its reefs as the product of carbonate deposition in a temperate water environment. A trend of increasing number and size of stromatoporoids westwards from the vicinity of Albany, N.Y. (where they are rare and small) to Hagarsville, Ontario, Canada (where they are common and large) due to the assumed solar warming of coastal currents flowing from east to west supports this hypothesis (Wolosz, 1990b). Further evidence of this warming includes the first appearance of algae (Rothpletzella) in the vicinity of the LeRoy bioherm, LeRoy, N.Y. Carbon and oxygen isotopic analyses of brachiopods from the Edgecliff further support a cool water model for reef deposition (see attached Figure 1 for graphical representation of isotope data and comparison to Middle Devonian O^{18} range from Popp, et al., 1986, Journ. Sedimentary Petrol., v.56, pp.715-728). Further, shallow water facies have now been identified in the Edgecliff near Port Colborne, Ontario (Wolosz, 1991a), putting to rest the argument that no peritidal facies exist in the Edgecliff.

B) Description of the various modes of Edgecliff reef growth and their controlling factors. The Edgecliff reefs have been subdivided into five distinct growth patterns, each representing growth under distinct conditions of water depth, which fit into a distinct paleogeographic framework (Wolosz, 1992). Recognition of these reef growth patterns, in conjunction with understanding of the successional patterns of the mound building organisms (Wolosz, in press a, in revision), allows for the use of the reefs in the interpretation of basinal dynamics during reef growth.

C) Nature of the "pinnacle reefs". A model based upon the one available pinnacle reef core, and the Mt. Tom exposure which has been identified as a "little pinnacle reef" indicates that these structures would be better termed "micro-banks" than pinnacle reefs (Wolosz, et al., 1991). While coral growth is the most visibly impressive feature of these reefs, crinoidal grainstone/packstone is by far the most important feature volumetrically. The flat top topography (based on seismic data) of these structures, in conjunction with the volumetric importance of the crinoidal sediments (especially as matrix surrounding coral colonies in all but the early stage of "reef" growth) strongly suggests coral thickets capping a large bank, with lateral growth due to sediment being shed off-bank into deeper surrounding waters.

D) Basinal dynamics and distribution of Pinnacle reefs. As mentioned above, reef growth patterns follow distinct regional trends (Wolosz, 1992). Reef growth started in the eastern half of New York State, rimming the basinal axis. A low landmass or series of islands (evidenced by subaerial erosion of the underlying rock units) separated the eastern basin from a shallow water embayment (arm of the Appalachian sea) in which quiet water calcisilt mounds grew (Wolosz, 1988). A westwards shifting of the basinal axis resulted in subsidence in the center of the state and the formation of pinnacle "reefs". The low central landmass was submerged, resulting in the Edgecliff "transgression", and the erosion of the calcisilt mounds under higher energy conditions. At this point in time the Edgecliff to the west of the string of pinnacle reefs was deposited on a broad, shallow shelf, which produced only low, shield-shaped buildups. Further to the west, in the vicinity of Port Colborne, Ontario, Canada, only very shallow water structures are found (Wolosz, 1990a).

A question commonly asked by explorationists has been "Why are there no pinnacle reefs along the eastern side of the basinal axis?" The answer lies in an understanding of the asymmetric dynamics of the basin and the nature of these reefs (Wolosz, in press b). While some reefs are rooted in the underlying micritic "Cl" facies of the Edgecliff, all reefs appear to have had their growth initiated either within or extremely close to the boundary with typical Edgecliff grainstone/packstones. Hence, the water depth of the facies transition between "Cl" deposition and grainstone/packstone deposition would also be the critical depth for reef initiation. The subsurface pinnacle reefs originated well above this depth, in shallow water on, or near, the disconformity at the base of the Edgecliff, with upwards growth controlled by subsidence in the area as the basin axis shifted to the west. All large eastern reefs (Mt. Tom, Roberts Hill) are positioned well up the ramp (see Mesolella, 1978, Amer. Assoc. Petrol. Geol. Bull., v.62, pp.1640-1641), and underlain by the micritic "C1" Edgecliff facies, indicating shallowing in the area prior to the onset of reef growth, followed either by subsidence during reef growth (Mt. Tom - a "mini-pinnacle reef") or predominantly shallow water conditions (Roberts Hill). However, shallowing in the east never proceeded far enough down ramp to allow reef initiation in areas of maximum subsidence. As a result, eastern reefs were limited to areas of only moderate subsidence and therefore never achieved large size.

E) Diagenesis

Cementation patterns within the Edgecliff reefs are for the most part simple. Cathodoluminescence reveals that almost all pore filling cements follow a standard dark non-luminescent, bright luminescent, dull luminescent cement sequence from the edge to the center of the pore with repetitive cycles being extremely rare. Late, dull luminescent cements generally make up the bulk of the cement in any pore, with dark non-luminescent cements common as initial cement crystals, but with only thin rims of bright cement along the edges of the dark crystals.

Early cement crusts are extremely rare and limited to the shallowest water grainstone/packstones or to lining of stromatactis-like structures within calcisilt mounds (LeRoy Bioherm). These patterns of cementation are very similar to those described by James and Bone (1989, Jour. of Sedimentary Petrology, v. 59, p.191-203) for temperate water calcarenites from southern Australia.

Examination of all surface exposures indicates that porosity preservation within the Edgecliff reefs is a function of the later draping of the reef structure by shaley limestones or shales. This conclusion is based on excellent porosity preservation within both the largest known surface exposure (Mt. Tom) and one of the smallest and shallowest water structures (Ridgemount Bioherm). At Mt. Tom, the base of the reef is tightly cemented, but primary porosity is preserved in the upper parts of the structure - a pattern characteristic of the subsurface pinnacle reefs (personal communication, Jerold Bastedo, formerly of Empire Exploration, Buffalo, N.Y.) Mt. Tom was draped by the shaley Nedrow Member of the Onondaga. Near Fort Erie, Ontario, Canada, the Ridgemount Bioherm is capped by a shaley limestone and preserves excellent primary porosity, while an overlying grainstone/packstone bed (approximately 3 meters stratigraphically above the bioherm) is tightly cemented. Reefs entirely enclosed within the basal packstone grainstone of the Edgecliff generally are tightly cemented or exhibit only minor and patchy primary porosity.

Isotopic analysis of the dull cements from seven surface exposures indicate that pore-occluding cements formed under different conditions from those which rim preserved pores. Figure 2 illustrates all data for dull cements. Note that all eastern reef values clump between O^{18} values of roughly -6 to -10 and C^{13} values of 1.5 to 3.5; while analyses from Mt. Tom and western reefs range much more widely. Figure 3 illustrates data from just Mt. Tom and the western reefs. Note that Mt. Tom and western reef dull cement samples can be divided into two groups: pore-filling cements and pore-lining cements (lining a preserved primary pore). In both cases the Mt. Tom and western reef pore-filling cements have an isotopic signature nearly identical to those of the tightly cemented eastern reefs; while pore-lining cements from Mt. Tom are isotopically heavier and those from the west isotopically lighter than the pore-filling cements indicating significantly different pore-water chemistries.

PUBLICATIONS TO DATE

in revision, Thicketing Events - a key to understanding the ecology of the Edgecliff Reefs (Middle Devonian Onondaga Formation of New York and Ontario, Canada), in, Brett, C.E. (ed.), Paleontological Event Horizons, Columbia University Press.

in press a, Turbulence Controlled Succession in the Middle Devonian Edgecliff Reefs of Eastern New York State, Lethaia.

1992 Patterns of reef growth in the Middle Devonian Edgecliff Member of the Onondaga Formation of New York and Ontario, Canada and their ecological significance, Journal of Paleontology, 1:8-15.

1991 Understanding the East Central Onondaga Formation (Middle Devonian) - An examination of the facies and brachiopod communities of the Cherry Valley Section, and Mt. Tom, a small pinnacle reef, New York State Geological Association Field Trip Guidebook,

63rd Annual Meeting, pp.373-412. (senior author, with Howard R. Feldman, Richard H. Lindemann, and Douglas E. Paquette).

1990a Shallow water reefs of the Middle Devonian Edgecliff member of the Onondaga Formation, Port Colborne, Ontario, Canada, New York State Geological Association Field Trip Guidebook, 62nd Annual Meeting, pp.Sun.E1-Sun.E17.

ABSTRACTS OF PAPERS PRESENTED AT SCIENTIFIC MEETINGS

in press b, Basin dynamics - controls on location of Edgecliff pinnacle reefs, (to be presented at Annual Meeting of American Association of Petroleum Geologists, Calgary, Alberta, Canada, June, 1992).

1991a Shallow, temperate water facies of the Edgecliff Member, Onondaga Formation (Middle Devonian). Port Colborne, Ontario, Canada, Geological Society of America, Abstracts with Program, v.23, no. 5, p.A227.

1991b Edgecliff Reefs - Devonian Temperate Water Carbonate Deposition, American Association of Petroleum Geologists Bulletin, v.75, no.3, p.696.

1990b Edgecliff reefs of New York and Ontario, Canada - Middle Devonian Temperate water bioherms, Geological Society of America, Abstracts with Program, v.22, no. 7, p.A220.

1989 Thicketing events - a Key to Understanding Edgecliff Reefs, Geological Society of America, Abstracts with Program, v.21, no.2, p.77.

1989 Water Turbulence - The Controlling Factor Within Colonial Rugosan Successions Within Edgecliff Reefs, Geological Society of America, Abstracts with Program, v.21, no.2, p.77.

1988 Variations in Northern Appalachian Basinal Dynamics Determined by Rugosan Coral reef Successions - Middle Devonian Edgecliff Limestone (Onondaga Formation, New York), Geological Society of America, Abstracts with Program, v.20, no.7, p.A122.

1988 The Leroy bioherm: a reactivated Devonian reef (Edgecliff Member, Onondaga Formation), Geological Society of America, Abstracts with Programs, v.20, no. 1., p.80.

Figure 1.

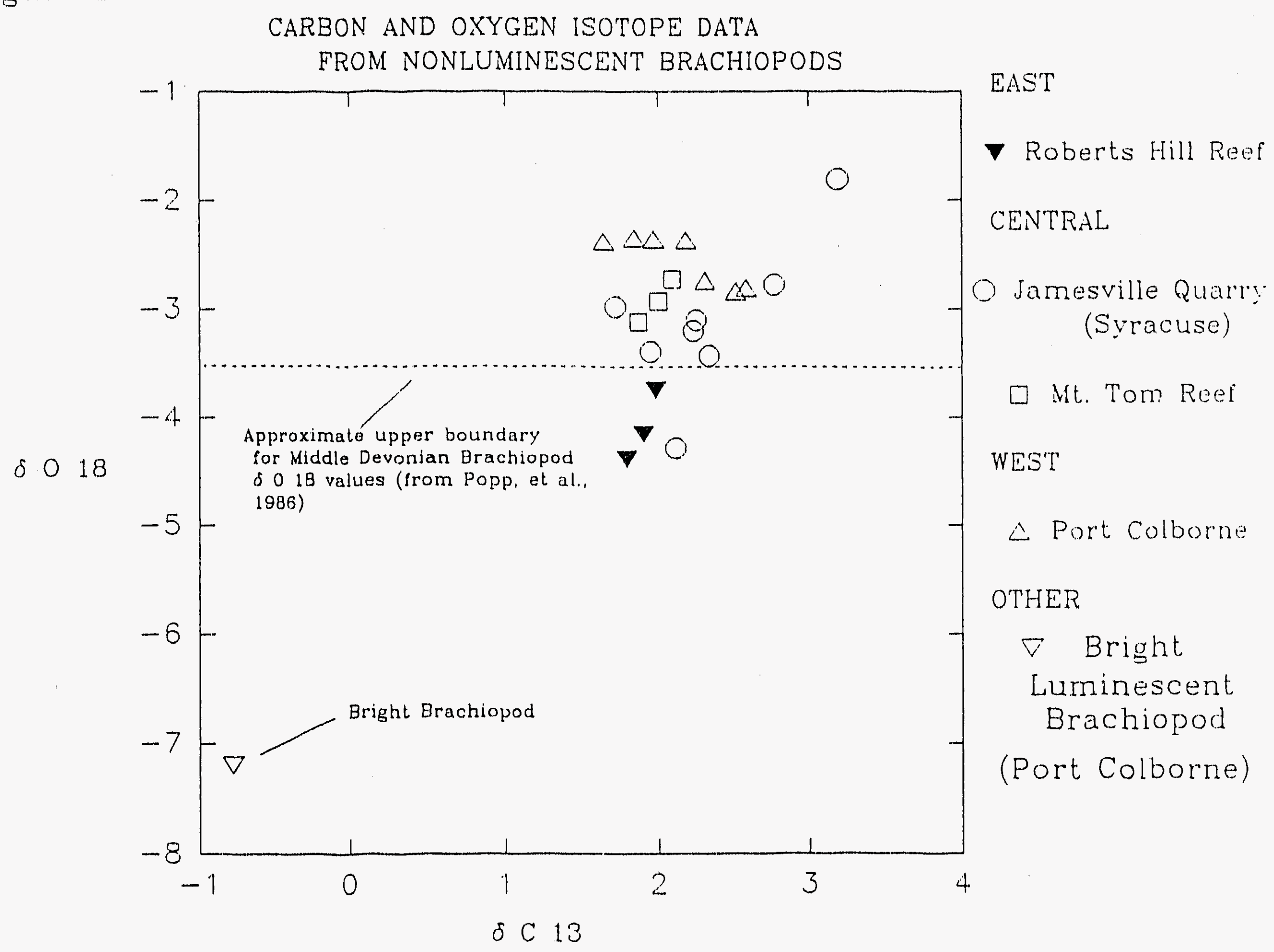

CARBON AND OXYGEN ISOTOPE DATA
FROM NONLUMINESCENT BRACHIOPODS
δ O 18
δ C 13
−1
−2
−3
−4
−5
−6
−7
−8
−1
0
1
2
3
4
Approximate upper boundary for Middle Devonian Brachiopod δ O 18 values (from Popp, et al., 1986)
Bright Brachiopod
EAST
Roberts Hill Reef
CENTRAL
Jamesville Quarry (Syracuse)
Mt. Tom Reef
WEST
Port Colborne
OTHER
Bright Luminescent Brachiopod
(Port Colborne)

Figure 2.

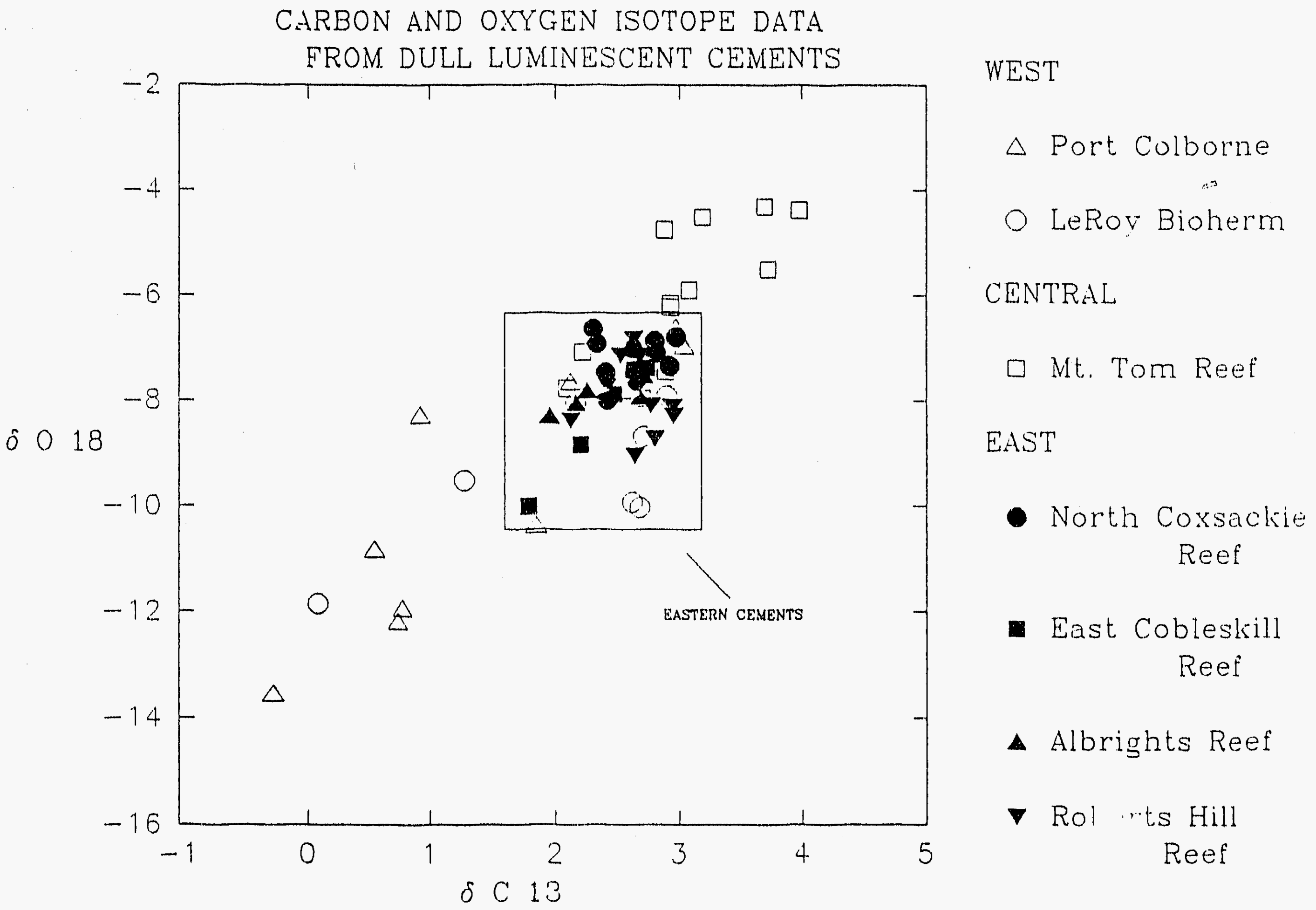

CARBON AND OXYGEN ISOTOPE DATA
FROM DULL LUMINESCENT CEMENTS
δ O 18
δ C 13
-2
-4
-6
-8
-10
-12
-14
-16
-1
0
1
2
3
4
5
EASTERN CEMENTS
WEST
Port Colborne
LeRoy Bioherm
CENTRAL
Mt. Tom Reef
EAST
North Coxsackie Reef
East Cobleskill Reef
Albrights Reef
Reef

Figure 3.

CARBON AND OXYGEN ISOTOPE DATA FROM DULL LUMINESCENT CEMENTS

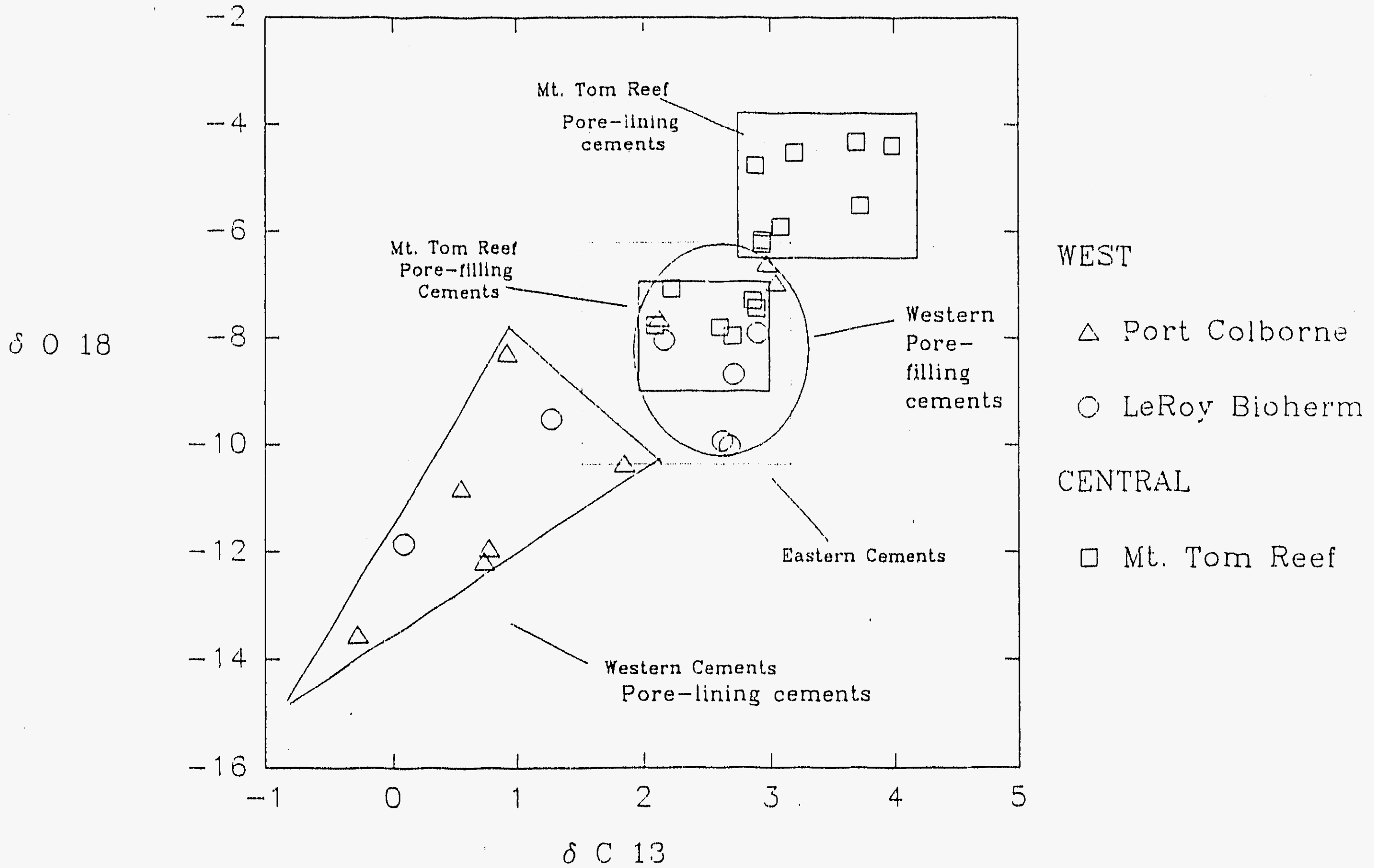
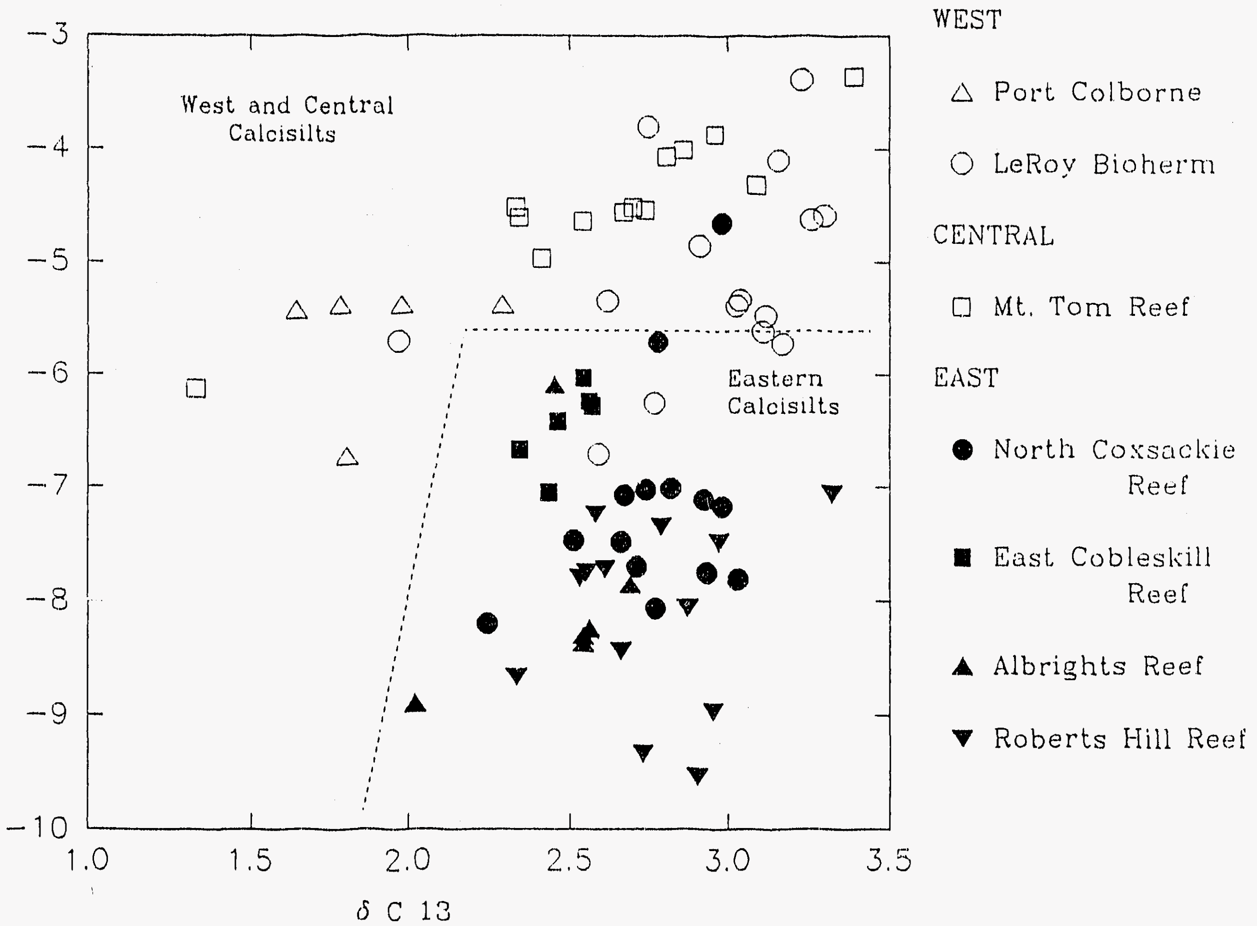


Figure 4.

CARBON AND OXYGEN ISOTOPE DATA FROM CALCISILT SAMPLES



END

DATE
FILMED
6 / 04 / 92