FORAMINIFERA OF THE REPETTO HILLS

by

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INTRODUCTION.

The use of Foraminifera for correlation purposes has rapidly increased during the past eight years. The Foraminiferal assemblages for the Miocene, Pliocene, Pleistocene and Recent epochs have been studied rather fully by the micropaleontologists of several of the oil companies located in Los Angeles, California. Less is known of the Foraminifera of the Oligocene, Eocene and Cretaceous of the Pacific coast.

While examples of short range species can be cited, in general it is true that Foraminifera are long ranged. Since this is the case, numerous discussions have consequently arizen concerning the value and dependability of correlations based on their use.

The preceding paragraphs indicate some of the reasons why the present study has been undertaken. First it was desired to identify the Foraminifera of the lower Pliocene; second to determine whether this group is distinctive of the lower Pliocene, and hence to learn whether correlations based on identification of assemblages of Foraminifera are dependable and valuable.

In the prosecution of Foraminiferal studies, it has been the practice of many micropaleontologists working in the Los Angeles district, to identify the genera and to assign a file number to the individual species. The writer understands that this system has been followed for two reasons, viz: the simplification that abbreviation permits, and that attempts to identify species without access to holotype or topotype material for purposes of comparison are dangerous. The writer has had the temerity to make specific identifications of the Foraminifera mentioned and illustrated in this page. It was thought that the results of the work would be increased thereby, even though the species identified might be found to vary slightly from the holotype forms, should they be compared with them. The reader may make the

reservation of reading the included list of Foraminifera as "Genus cf. species" if he so desires.

Acknowledgment is hereby made to George H. Doane for his generous assistance in the identification of the species mentioned in this paper, and to Frank W. Bell of the California Institute of Technology for his valuable suggestions concerning laboratory methods for handling Foraminifera.

LOCATION AND DESCRIPTION OF REPETTO SECTION.

The Repetto Hills are located in Los Angeles County, California. They occupy the central and western portion of the south half of T. 1 S., R. 12 W. This area is approximately five miles east of the city of Los Angeles and 1 to 2 miles southwest of Alhambra.

The Repetto Hills present a rather complete stratigraphic section of the lower Pliocene rocks. In the Los Angeles Basin there is no other outcrop of this formation containing a micro-faunal record of equal completeness. Since the old term "Pico", proposed by Kew for the Pliocene beds exposed in Pico canyon, includes both lower and middle Pliocene, some geologists have advocated that the term "Repetto formation" should be used to expressly designate the lower Pliocene of the Los Angeles Basin. In this paper it will be used in that sense.

A cross section of the formations occurring in the Repetto Hills was made, commencing at the intersection of Garvey Avenue with Atlantic Boulevard, and proceeding in a direction approximately S. 20° W. to the high tension transmission line of the Southern California Edison Company.

By reason of the deep notches cut into the sides of the hills during a period of road construction, good and almost continuous exposures of the strata are afforded for the taking of strike and dip observations, and for the collection of samples containing Foraminifera.

Figure 1 accompanying this paper shows the location of the Repetto Hills with respect to other nearby features of Los Angeles County. The position and course of the cross section is also shown. Figure 2 is a plan view on a larger scale of the traverse from which the cross section is derived. It gives the exact location at which samples were taken, and also indicates observations on the attitude of the strata. The cross section itself is shown in Figure 3.

LITHOLOGY.

The strata at Repetto Hills present a rather monotonous aspect. They are composed almost entirely of silt, of a dull, light tan to light buff color. The material is poorly consolidated, and if fragments of it are placed in water they will disintegrate almost completely.

The measured section gives a total of 3,515 feet. Four thin beds of conglomerate sandstone occur in the upper third of the exposed strata. The position of these sandy beds may be seen on figure 3. The material composing them grades from pebbles of 2 inches maximum diameter, downward through granule size, coarse sand and silt. It is, therefore, very poorly sorted. The lower three beds of conglomerate sandstone measure 4½ feet thick each. The upper one is approximately 1 foot thick and contains upper Pliocene fauna -#1 - pecten, turritella, ostrea, etc. Aside from the sandy layers mentioned the section consists of silty material grading from sandy silt to clay silt.

Foraminifera are present thruout the section but not in great abundance. Occasionally "stratum layers" (15) may be found in which they are common, but the exposures as a whole are not very fossiliferous.

#1. The writer has a collection of fossils from this horizon, which has not been completely identified as yet. The paleontologists for the Standard Oil Company of California, the Texas Company, and the Shell Oil Company of California have made collections from this bed and have identified the fossil content as being of upper Pliocene age. Oral communications.

The Foraminifera show a rather distinctive preservation. They are of a yellowish to buff color, with a dull or unpolished exterior, seldom possessing the translucent, vitreous or hyaline appearance so common in many micro-faunas of various other localities. Many of the forms are partially or completely filled with hydrated iron oxide. Globobulimina pacifica Cushman, as an example, appears to have a special affinity for limonite. The internal chambers of this species are almost always partially or wholly filled with it, which gives the fossil a characteristic coffee brown color. Many other Foraminifera show the same characteristic to a lesser extent.

Concretionary structures are occasionally present in the strata. In shape they are post-like, oval; or they may occur in a series of thin lenses along a single bedding plane. These concretions have not been studied in detail, but their formation is subsequent to the deposition of the strata, since Foraminifera and worm borings are well preserved in them.

The lower third of the horizons exposed at Repetto Hills is replete with worm borings. In the upper two thirds of the section they are not common.

STRATIGRAPHY.

The contact of the lower Pliocene with the upper Miocene is not exposed in the Repetto Hills at the locality selected for the cross section. It may be seen, however, farther to the west. If the contact is projected eastward from there with unchanged strike it will pass a short distance north of the type section thru an area of no outcrops.

Either a two-fold or a three-fold subdivision of the Pliocene can be made at Repetto Hills. On the basis of lithology the entire exposure is essentially a unit. The whole series shows a conformable sequence.

The four thin conglomerate sand beds in the upper part of the section are so insignificant that they cannot be followed out laterally for any great distance.

On the bases of micro-faunal content, however, a better subdivision is possible. The upper 400 feet of the measured section are upper Pliocene. The base is marked by a 1 foot conglomeratic sand layer carrying macro-fossils such as pecten, ostrea and turritella.

The 700 feet of strata immediately underlying the upper Pliocene contain a micro-fauna transitional between lower and upper Pliocene, with a much stronger affinity for the lower Pliocene than for the upper. Since these 700 feet of strata can be separated from those above and below, one may if he desires set them apart as a separate unit and call them "transition" beds. However, in view of their strong micro-faunal affinity for the lower Pliocene they will be included with the latter in this paper. These beds contain three conglomeratic sand layers, each approximately $4\frac{1}{2}$ feet thick.

The remainder of the section, which lies below the 700 feet of strata just described, gives a measured thickness of 2380 feet. This is of lower Pliocene age. It consists entirely of silt. The micro-faunal content of these beds is unusual and distinctive, and is rapidly becoming known as the "Repetto Fauna"; the beds themselves as the Repetto formation. In the writer's opinion the Repetto formation should include all of the strata from the top of the transition beds to the bottom of the exposed section, and in addition should include the balance of the lower Pliocene beds represented elsewhere in the Repetto Hills, which intervene between the measured section and the top of the Miocene. This would give a total thickness of more than 3,100 feet, possibly as much as 3,500 feet.

In figure 3 the Repetto formation extends from point A to the conglomeratic sandy bed immediately above BD. The upper Pliocene includes

all beds shown above this point.

FORAMINIFERA. GENERAL STATEMENT.

Foraminifera live in a marine environment, and their remains in a sediment imply a marine origin for the strata in which they are found. They are one celled animals belonging to the Phylum Protozoa.

The shell or covering is called a "test". In some forms this is composed of cemented or agglutinated foreign material, as in the arenaceous forms. In others it consists of chitin or calcareous material. The test is single or multiple chambered.

The animal is capable of locomotion by means of pseudopodia, which are projected through the foramina for that purpose and for feeding. Egress from the test is effected through the aperture. When the animal is disturbed, the extended portions of the protoplasm and pseudopodia may be drawn back into the test for protection.

Foraminifera undergo an alteration of generations. The life cycle will not be described here, as it is discussed in many texts. It is sufficient to mention that species have two forms, the megalospheric and the microspheric. The former is smaller than the latter usually, but has a much larger proloculum (first chamber). The microspheric form begins its individual life with a very small proloculum and sometimes shows a more complex arrangement of the early chambers. It is sometimes difficult to recognize that the two forms are representative of the same species.

Most Foraminifera are bottom-living in habit. Some forms become fixed or attached to an object, while others remain free moving. Still another type is pelagic. The family Globigerinidae is an example of the latter.

Many classifications of Foraminifera into families and genera have

been published. In this paper the latest by Joseph A. Cushman will be followed. In his classification Cushman has made a beginning toward a subdivision based on Phylogeny. The general basis of the classification incorporates three main factors which are, (1) material of which the test is composed; (2) arrangement of the chambers and their perforation; (3) position of the aperture. The multiple combinations of these three factors determines the subdivision into families. Additional data such as ornamentation of the test, nature of the sutures and many other considerations determine the genera and species.

According to the present accepted views concerning the Phylogeny of Foraminifera, the simplest forms are those without tests or those with thin chitinous tests. In the more advanced forms sand, sponge spicules or other foreign material is agglutinated or cemented together around the animal to form a test. The most advanced types are those capable of secreting calcareous tests about themselves.

Most of this data has been taken from Joseph A. Cushman's book, "Foraminifera, Their Classification and Economic Use."

REPETTO HILLS FORAMINIFERA.

In Cushman's latest classification there are 45 families of Foraminifera. Eleven of these families represented by 55 species were found in the Repetto Hills section.

The relative order of abundance of families is as follows: Buliminidae 17, Lagenidae 12, Globigerinidae 6, Anomalinidae 4, Cassidulinidae 4, Miliolidae 3, Rotaliidae 3, Nonionidae 2, Textulariidae 1, Heterohelicidae 1, Verneuilinidae 1.

Thus it appears that more than half of the species are represented by only three families. This particular grouping of families is said to be peculiar to the Pliocene. (2, page 125.)

The relative abundance of individuals of the various species does not conform to the order given above for families. The Lagenidae with twelve species are represented in abundance of individuals by only two, viz; Robulus cushmani and Glandulina laevigata. The Anomalinidae with four species, is represented only in great numbers thruout the section by Cibicides mckannai. Cassidulina california and Cassidulina translucens of the family Cassidulinidae are also very numerous. The family Buliminidae, however again leads the others with large numbers of individuals from various species of the genera Bulimina, Bolivina and Uvigerina. Gyroidina soldanii var. altiformis is found commonly thruout the Repetto formation. It is the only representative of the Rotaliidae in great numbers.

Table 1 on page 15 gives a list of the Foraminifera recognized in the Repetto Hills section. Localities where good representative fossil assemblages were obtained are shown on the table by letters, such as; B, K, AA1, BA, etc. The relative numbers of individuals for each of the species is indicated by the letters A, C, R, meaning abundant, common, rare, respectively. The collecting stations are arranged in this table from right to left, location B representing the lowest stratigraphic point from which material was collected, and BA the highest. The list of fossils is arranged so that one may see at a glance the disappearance and appearance of species in successively higher strata.

Immediately following will be found a list of the Foraminifera by family, genus and species. The various species are not described individually, but references are given (by number) to available literature where detailed descriptions may be had if desired.

MICROFAUNAL LIST.

Family Miliolidae.

Pyrgo sp?
Quinquiloculina seminulum (Linnaeus) 4.
Sigmoilinia elliptica Galloway & Wissler 1.

Family Nonionidae.

Nonion septaloba (Note 1).
Nonion umbilicatula (Montague) 2, 4, 7.

Family Lagenidae.

Nodosaria soluta Reuss 10.
Nodosaria elegans Schwager 14.
Nodosaria sp?
Lagena sulcata (Walker & Jacob) 2, 7.
Lagena substriata Williamson 2, 7.
Lagena williamsoni (Alcock) 2, 7.
Glandulina laevigata d'Orbigny 2, 7.
Fissurina laevigata Reuss 14.
Dentalina sp?
Robulus cushmani Galloway & Wissler 1.
Robulus sp?
Frondicularia advena Cushman 7.

Family Buliminidae.

Uvigerina pygmia d'Orbigny 4.
Uvigerina peregrina var. parvula Cushman 1.
Uvigerina gallowayi Cushman 11.
Uvigerina peregrina Cushman 2, 7.
Uvigerina proboscidia Schwager 7.
Bulimina inflata Seguanza 2, 4, 7.
Bulimina marginata d'Orbigny 1.
Bulimina buchiana d'Orbigny 14.
Angulogerina angulosa Williamson 13.
Bolivina marginata Cushman 9.
Bolivina subadvena Cushman var spissa Cushman 6.
Bolivina miocenica Cushman 13.
Bolivina beyrichi Reuss var. alata (Seguenza) 13.
Bolivina sinuata Galloway & Wissler 1.
Bolivina aeneriensis (Costa) 8.
Globobulimina pacifica Cushman 2, 7.
Virgulina schreibersiana Czjzek 2.

Family Anomalinidae.

Cibicides mckannai, Galloway & Wissler 1.
Planulina wuellerstorfi (Schwager) 11.
Cibicides lobatulus (Walker & Jacob) 10.
Planulina orbicularis d'Orbigny 13.

Family Cassidulinidae.

Cassidulina california Cushman and Hughes 5.
Cassidulina translucens Cushman and Hughes 5.
Pulvinulinella bradyana Cushman 2.
Ehrenbergina bradyi Cushman 2.

Family Globigerinidae.

Orbulina universa d'Orbigny 1, 2.
Globigerina bulloides d'Orbigny 1, 2.
Globigerina dubia Egger 14.
Globigerina irregularis (Note 1).
Globigerina pachyderma (Ehrenberg) 1.
Globigerina quadrilatera Galloway & Wissler 1.

Family Textularidae.

Textularia flintii Cushman 7.

Family Heterohelicidae.

Plectofrondicularia californica Cushman & Stewart 6, 7.

Family Verneuilinidae.

Clavulina communis var. pallida Cushman 7.

Family Rotaliidae.

Gyroidina soldanii d'Orbigny var. altiformis
Roscoe & K. Stewart 3.
Discorbis sp?
Valvulinaria sp?

Note 1. The Foraminifera referred to in this note are new species not yet described in the literature. They were discovered by micropaleontologists working in the Los Angeles Basin district, who have assigned various names or numbers to the fossils. The names used in this paper have been favored by some, but as yet the species names have not been officially designated.

ANALYSIS OF MICRO FAUNA.

The list just completed is thought to be fairly representative of the Repetto Hills section. No doubt many other species are present, but it is believed that all the forms occurring in abundance have been included. In order to verify this conclusion, the writer collected several additional samples, after the completion of the preliminary work. From these the Foraminifera were concentrated and studied. No new species were found to be numerous in them.

The second purpose of this study, that of evaluating the diagnostic qualifications of Foraminifera, has proved to be more difficult of realization. However, some conclusions will be offered accompanied by the data on which they are based.

LOCAL ZONES:

More samples were taken than the 56 recorded in the cross section. Whenever Foraminifera appeared to be present they were washed out of the sample and concentrated. In many samples Foraminifera were absent, in others only a few individuals of a few species were obtained. In still others numerous individuals of a few species were present. When samples were found which contained many individuals of many species, they were used in the construction of table 1.

This table, then, represents a generalized micro-faunal cross section of the Repetto Hills exposures, but not a detailed one. In order to obtain one more detailed, more samples would be required than were collected. With numerous samples, it is believed that a section could be constructed which would show many zones, distinct from one another in their faunal content. Some zones would be barren; others

would contain a few species developed in great numbers, while still others would be typified by assemblages of genera or species not recurring in other zones in the same proportions.

Such a detailed section has not been prepared for this report, because its primary purpose is to tabulate the Foraminifera composing the micro-fauna of the Repetto Hills. However, enough work has been done to permit the statement that a subdivision of the strata into micro-faunal zones is possible. Whether these same zones can be distinguished in other Pliocene sections of the Los Angeles Basin is not known.

FORMATIONS:

Table 1 shows that most of the species range from the lowest exposure upward to the base of the upper Pliocene. 16 species occurring in the lowest 2380 feet of the Repetto formation are not found in the overlying 700 feet. Of these 16 species 10 are rare and have little diagnostic value. However, the absence of the following species in the upper 700 feet of the Repetto formation and their abundance in the lower beds is significant; Bulimina inflata, Bulimina marginata, Bulimina buchiana, Bolivina sinuata and Bolivina aeneriensis. These same five species are absent in the upper Pliocene. Uvigerina proboscidea and Gyroidina soldanii var. altiformis, abundant in the lower beds are only present in the lower part of the "transition" (700 foot) zone.

The 700 foot zone introduces the species Quinquiloculina seminulum and Bolivina subadvena var. spissa. They are not found above or below. 21 species found in this zone do not occur in the upper Pliocene.

37 species out of the total of 55 found in the Repetto section

(including the 700 foot zone) are found to be limited to the Repetto formation.

The three species: Nonion septaloba, Uvigerina gallowayi and Uvigerina peregrina are found in the upper Pliocene but not below. In the lower Pliocene Cassidulina californica has a very small test, whereas in younger strata the test is much larger.

Since only the lowermost 400 feet of the upper Pliocene were sampled here, it is not fair to assume that the results just enumerated would hold good for the entire upper Pliocene. Foraminifera reported as present in the lower Pliocene and absent in the upper, might be found to be present elsewhere in higher strata. However, to offset this source of error it is equally probable that many new species would be found in the latter, which are not represented in the lower Pliocene.

SERIES:

In order to determine the diagnostic value of Foraminifera for use in the larger stratigraphic divisions, various published reports have been investigated. A rapid survey of the literature indicates that a majority of the forms listed in this paper as representative of the Repetto formation, also occur above and below the lower Pliocene.

J. J. Galloway and Stanley Wissler (1) list 35 species from the lower San Pedro, Pleistocene beds exposed at Lomita quarry, which they also find in the lower Pliocene. They mention 45 species common to upper Pliocene and Pleistocene. Bolivina sinuata, Frondicularia advena, Globigerina quadrilatera, Globobulimina pacifica and Robulus cushmani are mentioned as ranging from Miocene to Pleistocene. These five species occur in the Repetto Pliocene section as well as many of the others of lesser range. Bulimina inflata, one of the most characteristic and abundant of the lower Pliocene Foraminifera has been found to range

from Cretaceous to Recent. Plectofrondicularia californica, frequently mentioned as typical of the lower Pliocene has been found in a few cases in the upper Pliocene.

It would perhaps be unsafe to name a single species occurring in the Repetto formation, as being confined to that formation. The Globigerina, especially, appear to be of long range, and generally abundant.

The apparent anomaly which Foraminifera present, of being both long ranged and good horizon indicators, can be explained in only one way. The general and relative assemblages must be used for comparisons and contrasts. Old species die out and new species develope with Foraminifera as with larger fauna, but apparently not so abruptly.

CONCLUSIONS.

Notwithstanding the long range of Foraminifera, it is scarcely possible that all species will persist through several geological epochs and retain during that time the same specific characteristics and the same virility. It is equally difficult to conceive of a special set of eccologic conditions recurring after a long lapse of time, with the same species waiting to take advantage of it to flourish in proportional numbers.

From these theoretical considerations and from the facts presented, it is believed that Foraminifera are useful for correlation purposes. The areal extent over which such a correlation is reliable, is beyond the scope of this paper.

TABLE 1.

FORAMINIFERA.	COLLECTING STATIONS. BA	AW	AT	AR	AD	AB	AA1	X	K	B
	UP. Plio	Repetto								
Uvigerina peregrina Cushman	C									
Uvigerina gallowayi Cushman	C									
Nonion septaloba n. sp.	A									
Nodosaria soluta Reuss.	R				R	R	R	R		
Uvigerina pygmia d'Orbigny.	A		R		R	A				C
Uvigerina peregrina var. parvula Cushman.	C		R			C	C			C
Pyrgo sp?	R	R		R		R	R			
Cassidulina californica Cushman & Hughes.	A			R	C	C		R	R	
Cassidulina translucens Cushman & Hughes.	R	A			A	R	R	R		A
Cibicides mckannai Galloway & Wissler.	R	C	A	A	A	A	A	A	C	C
Glandulina laevigata d'Orbigny.	R	R		R	R	C	C	R	R	
Bolivina marginata Cushman.	C	C				C	C	C		R
Globigerina bulloides d'Orbigny.	C	A	C	C	C	C	C	C	C	
Globigerina dubia Egger.	C	A	C	R	C	C	C	C	C	
Globigerina irregularis.	C	A	A	R	C					
Globigerina pachyderma (Ehrenberg).	C	A		C	C	C	C	C	C	
Globigerina quadrilatera Galloway & Wissler.	C	A	C	C	C	C	C	C	C	
Bolivina miocenica Cushman.		C		A	A	A	C	A	C	C
Orbulina universa d'Orbigny.		C		C	R	C	C	R		
Nodosaria elegans Schwager.		R		C	R	C	C	C	R	R
Planulina wuellerstorfi (Schwager).		C		C	C	C	C			R
Virgulina schreibersiana Czjzek.		R			R	R	C	C		
Robulus cushmani Galloway & Wissler.		A						C		C
Globobulimina pacifica Cushman.		C	A	C	C	R	C	C		C
Pulvinulinella bradyana Cushman.		C			R	C	R			R
Textularia flintii Cushman.		R		R	R		R			
Quinqueloculina seminulum (Linnaeus).		A		R						
Frondicularia advena Cushman.		R	R	R		R	R	R		
Plectofrondicularia californica Cushman & Stewart.		R					R			
Sigmoilinia elliptica Galloway & Wissler.		C			R				C	
Lagena sulcata (Walker & Jacob).		R		R		R	R			
Nodosaria sp?		R			R	R	C	R		
Bolivina subadvena Cushman Var. spissa Cushman.		C								
Robulus sp?				R						
Clavulina communis d'Orbigny var. pallida Cushman.				R				R		
Uvigerina proboscidea Schwager.				A	R	C	C	A	C	R
Lagena substriata Williamson.				C		R	R	R		
Gyroidina soldanii var. altiformis R. & K.Stewart.				A	C	A	A	C	C	R
Bulimina inflata Seguenza.					C	A	C	A	C	R
Bolivina beyrichi Reuss var. alata (Seguenza).					R	R	R		C	R
Cibicides cf.lobatulus (Walker & Jacob).					R			R		
Fissurina laevigata Reuss.					R	R		R		
Bolivina sinuata Galloway & Wissler.					A	A	A	R		A
Bolivina aeneriensis (Costa)					A	A	A	C	C	A
Bulimina marginata Cushman.					C	A	R	R		
Bulimina buchiana d'Orbigny.						C	C	C		
Lagena williamsoni (Alcock).							R			
Dentalina sp?							R			
Angulogerina angulosa Williamson.								R		
Discorbis sp?								R		
Nonion umbilicatula (Montagu).										R
Valvinularia sp?										R
Ehrenburgina bradyi Cushman.										R
Planulina orbicularis d'Orbigny.										R

EXPLANATION OF PLATES.

PLATE I.

1 a-c. Gyroidana soldanii var. altiformis Roscoe E and K. Stewart X 67.
a, Ventral view; b, dorsal view; c, peripheral view.

2 a,b. Bulimina inflata Seguenza. X 67.
a, b, Side views.

3 a-c. Bolivina miocenica Cushman X 67.
a, Side view; b, edge view; c, apertural view.

4 a,b. Uvigerina proboscidea Schwager. X 67.
a, b, Side views.

5 a-c. Clavulina communis d'Orbigny var. pallida Cushman. X 67.
a, Side view; b, apertural view; c, thin section.

6 a, b. Bolivina marginata Cushman. X 67.
a, Side view; b, apertural view.

7. Orbulina universa d'Orbigny. X 67. Side view.

8. Nodosaria elegans Schwager. X 67. Side view.

9 a,b. Glandulina laevigata d'Orbigny. X 67.
a, Side view; b, apertural view.

10 a-c. Planulina wuellerstorfi (Schwager). X 67.
a, Ventral view; b, dorsal view; c, peripheral view.

11 a-c. Cibicides mckannai Galloway & Wissler. X 67.
a, Ventral view; b, dorsal view; c, peripheral view.

PLATE II.

1 a-c. Cassidulina translucens Cushman & Hughes. X 67.
a, Side view; c, peripheral view.

2 a-c. Cassidulina californica Cushman & Hughes. X 67.
a, peripheral view; c, Side view.

3. Virgulina schreibersiana Czjzek. X 67. Side view.

4 a-c. Cibicides cf. lobatulus (Walker and Jacob). X 67.
a, Dorsal view; b, ventral view; c, peripheral view.

5. Lagena substriata Williamson. X 67. Side view.

6. Lagena williamsoni (Alcock). X 67. Side view.

7 a,b. Fissurina laevigata Reuss. X 67.
a, Side view; b, apertural view.

8 a,b. Robulus cushmani Galloway & Wissler. X 67.
a, Side view; b, peripheral view.

9 a,b. Globobulimina pacifica Cushman. X 67.
a, Side view; b, apertural view.

PLATE III.

1 a-c. Planulina orbicularis d'Orbigny. X 60.
a, Dorsal view; b, ventral view; c, peripheral view.

2 a-c. Ehrenbergina cf. bradyi Cushman. X 60.
a and b, Two sides; c, apertural view.

3 a,b. Bolivina beyrichi Reuss var. alata (Seguenza). X 60.
a and b, Side views.

4 a,b. Bolivina sinuata Galloway & Wissler. X 60.
a, Apertural view; b, side view.

5 a-c. Pulvinulinella bradyana Cushman. X 60.
a, Ventral view; b, dorsal view; c, peripheral view.

6 a,b. Bolivina aeneriensis (Costa). X 60.
a, Side view; b, apertural view.

7 a,b. Bulimina marginata d'Orbigny. X 60.
a and b, Two sides.

8. Bulimina buchiana d'Orbigny. X 60. Side view.

9. Uvigerina peregrina Cushman. X 60. Front view.

10. Uvigerina gallowayi Cushman. X 60. Front view.

11. Pyrgo sp? X 60. Side view.

12. Uvigerina peregrina var. parvula Cushman. X 60. Front view.

13. Uvigerina pygmia d'Orbigny. X 60. Front view.

PLATE IV.

1 a,b. Globigerina bulloides d'Orbigny. X 100.
a, Ventral view; b, dorsal view.

2 a,b. Globigerina dubia Egger. X 100.
a, Dorsal view; b, ventral view.

3 a-c. Globigerina irregularis. X 100.
a, b and c, Side views.

4 a-c. Globigerina pachyderma (Ehrenberg). X 100.
a, Ventral view; b, dorsal view; c, peripheral view.

5 a,b. Globigerina quadrilatera Galloway and Wissler. X 100.
a, Dorsal view; b, ventral view.

6 a-c. Textularia flintii Cushman. X 100.
a, Front view; b, apertural view; c, apertural view.

PLATE V.

1 a-c. Robulus sp? X 100.
a, Side view; b and c, apertural view.

2 a,b. Nodosaria cf. soluta (Reuss). X 100.
a, Apertural view; b, side view.

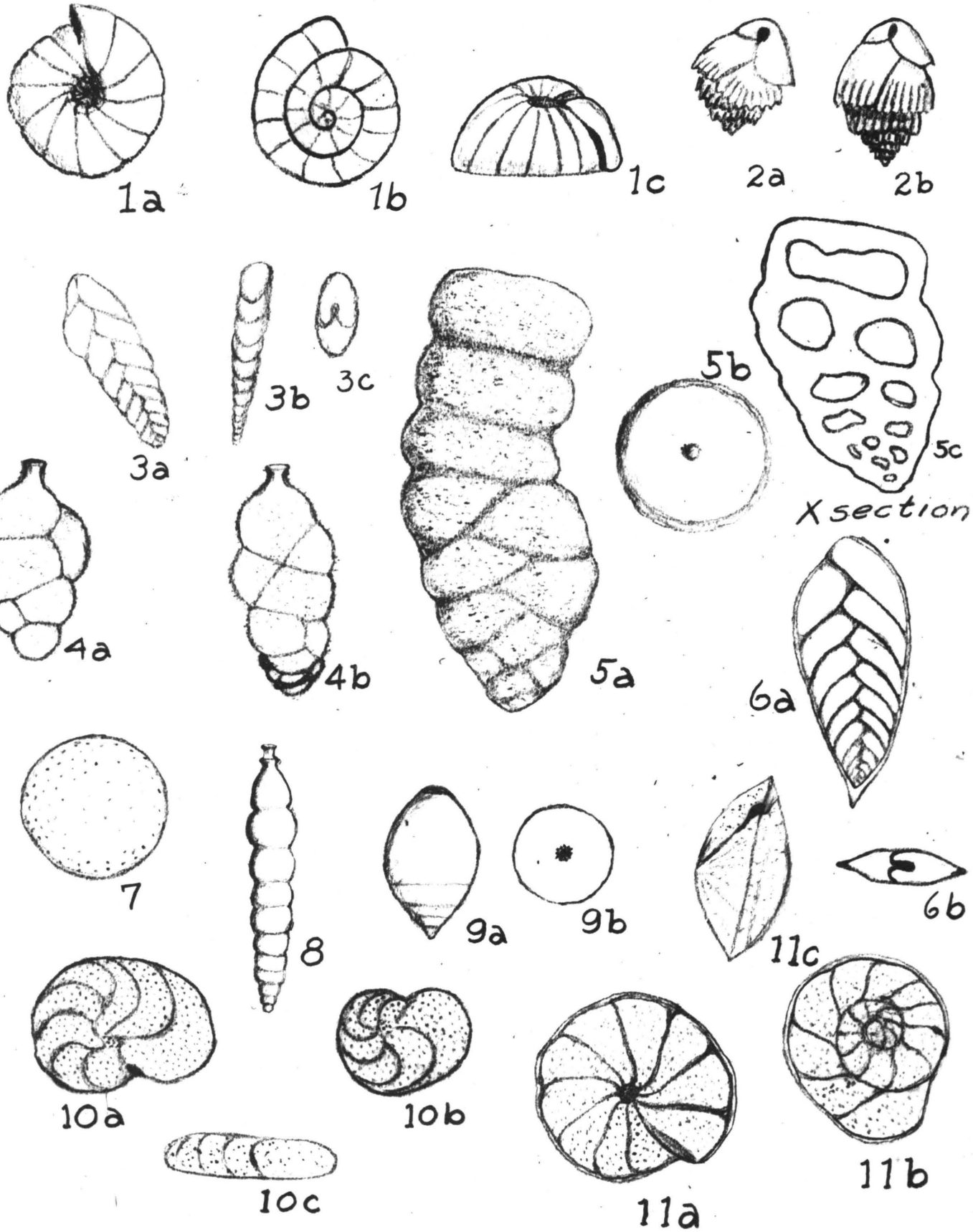
3 a-c. Quinquiloculina seminulum (Linnaeus). X 100.
a,c, Side views; b, apertural view.

4 a,b. Plectofrondicularia californica Cushman and Stewart. X 100.
a, Front view; b, cross section.

5 a,b. Nonion septaloba n. sp. (Note 1.) X 100.
a, Side view; b, peripheral view.

6 a,b. Frondicularia advena Cushman. X 65.
a, Front view; b, end view.

PLATE I


1a
1b
1c
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2b
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3b
3c
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4b
5a
5b
5c
X section
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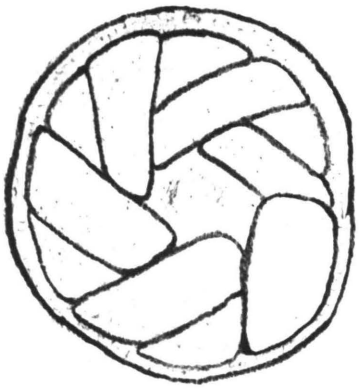
6b
7
8
9a
9b
10a
10b
10c
11a
11b
11c

PLATE II



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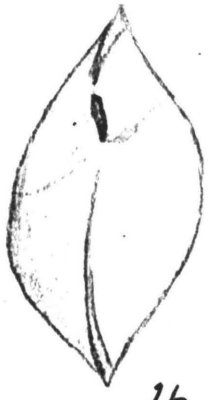

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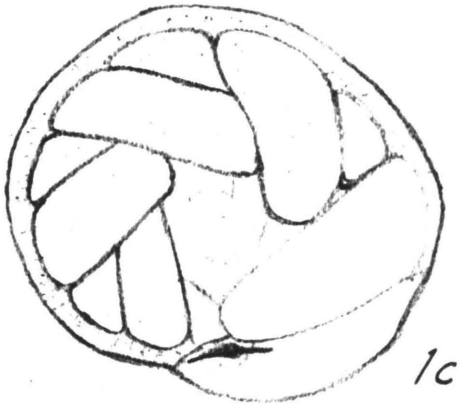

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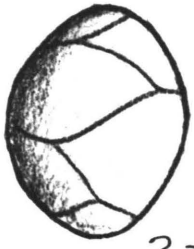

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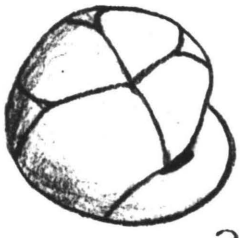

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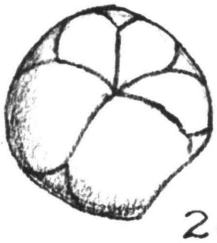

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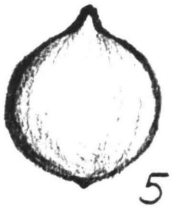

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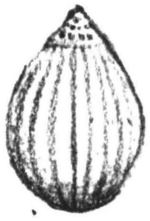

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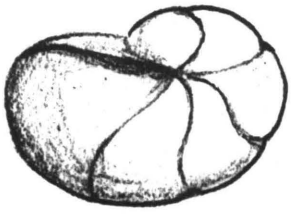

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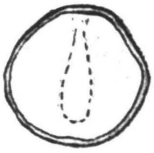

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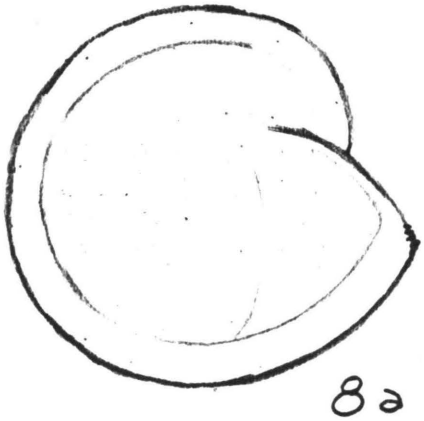

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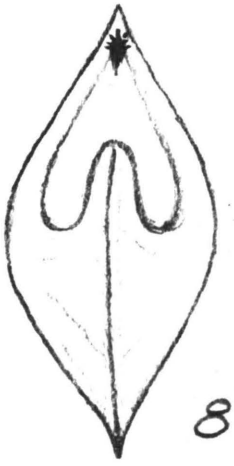

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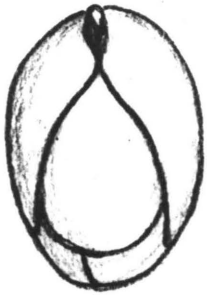

9a

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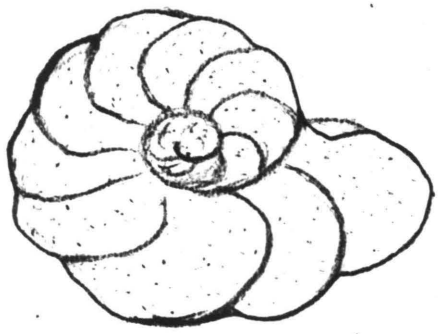

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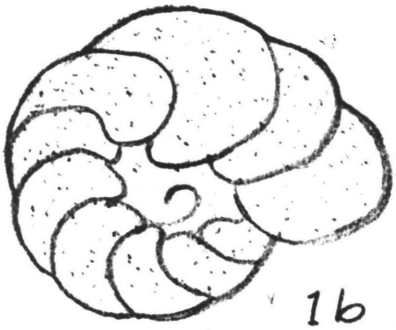

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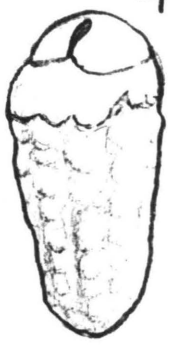
1c

3a

3b



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5a

5b

5c

4b

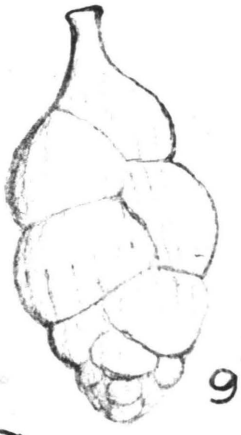
6a

6b

7a

7b

8



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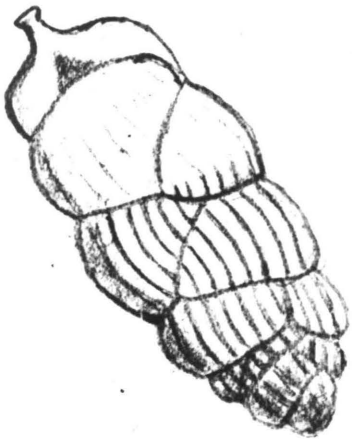

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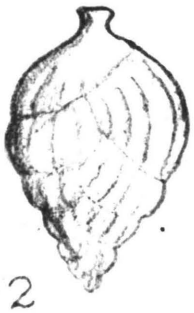

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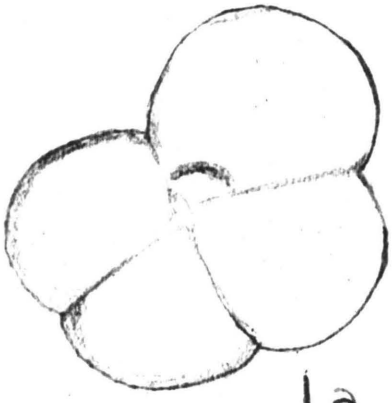
PLATE IV



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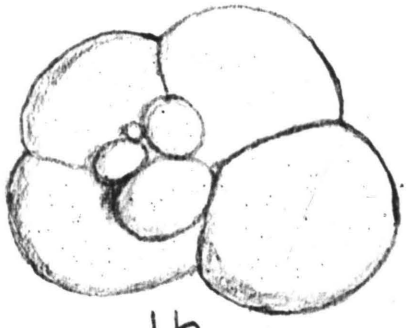

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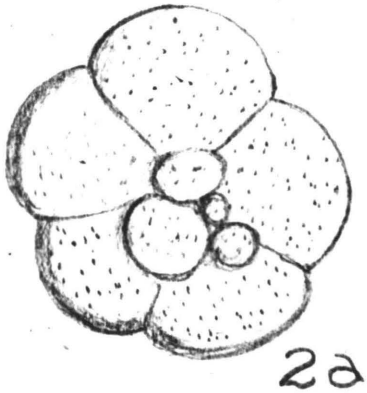

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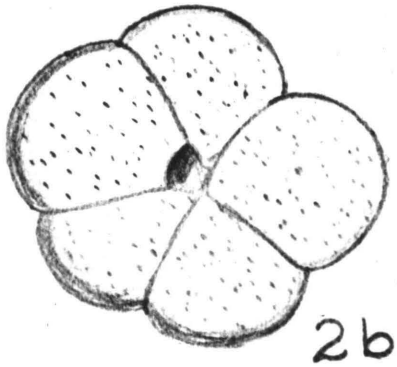

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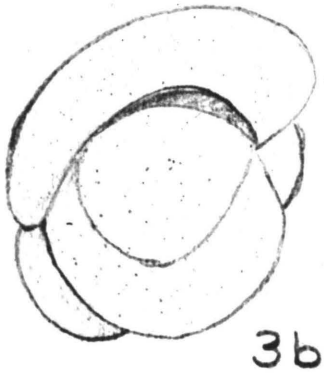

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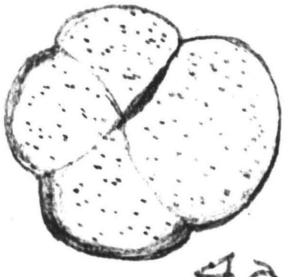

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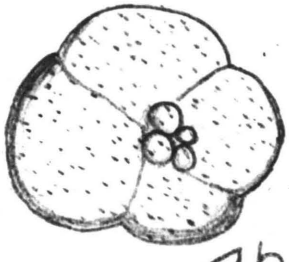

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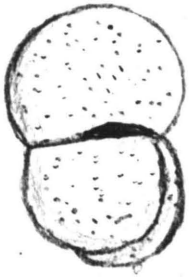

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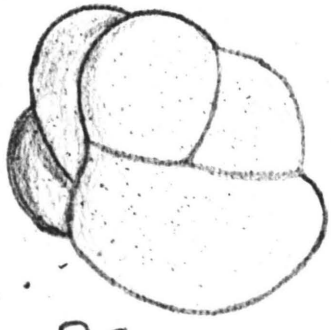

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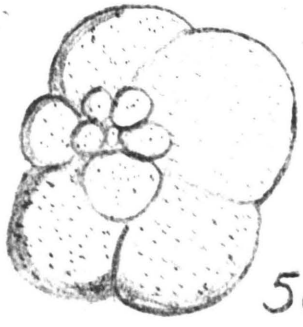

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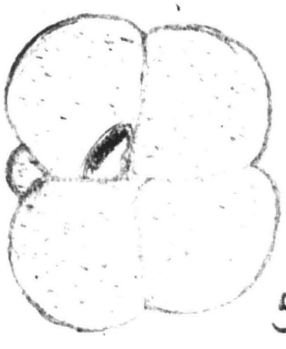

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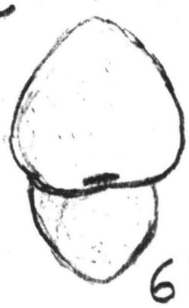

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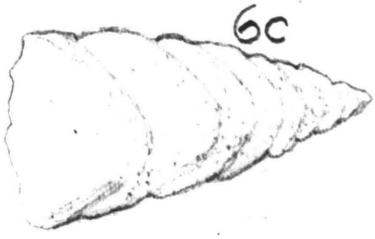

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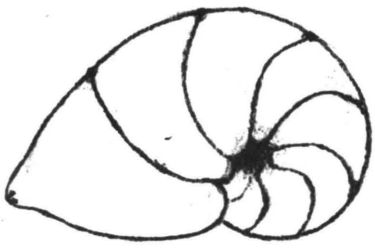
PLATE V.



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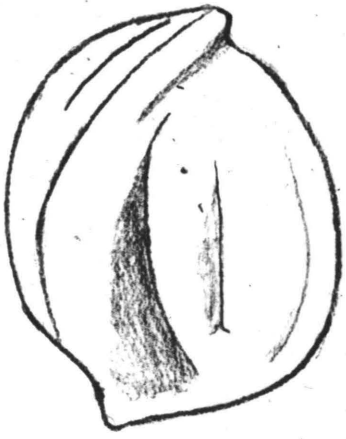
1b

1c

2a

2b



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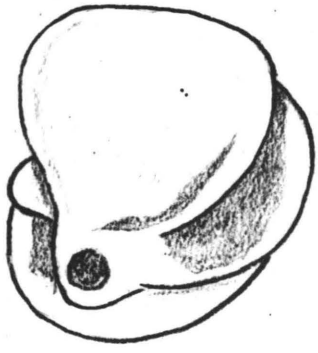

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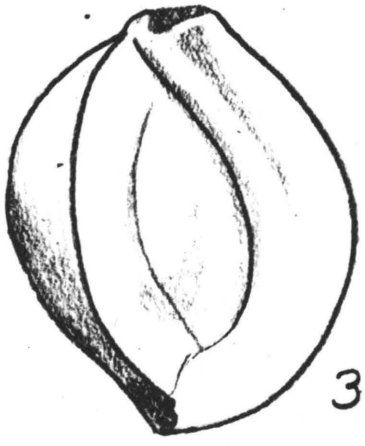

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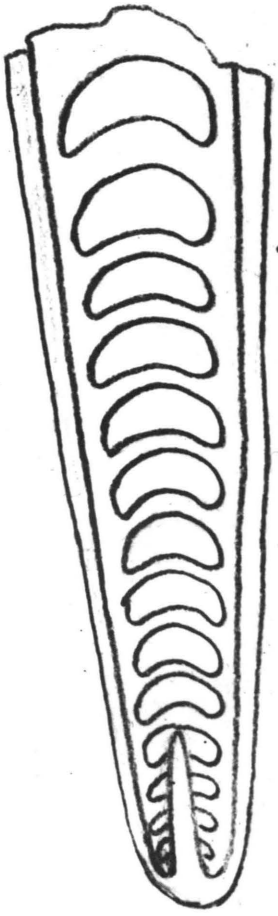

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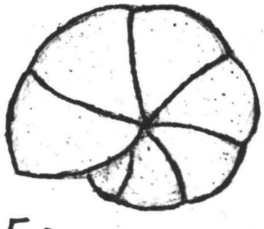

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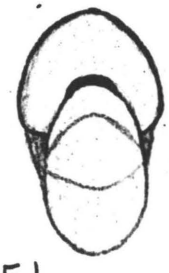

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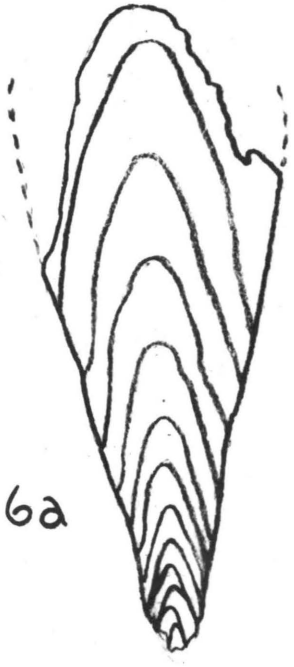
6b



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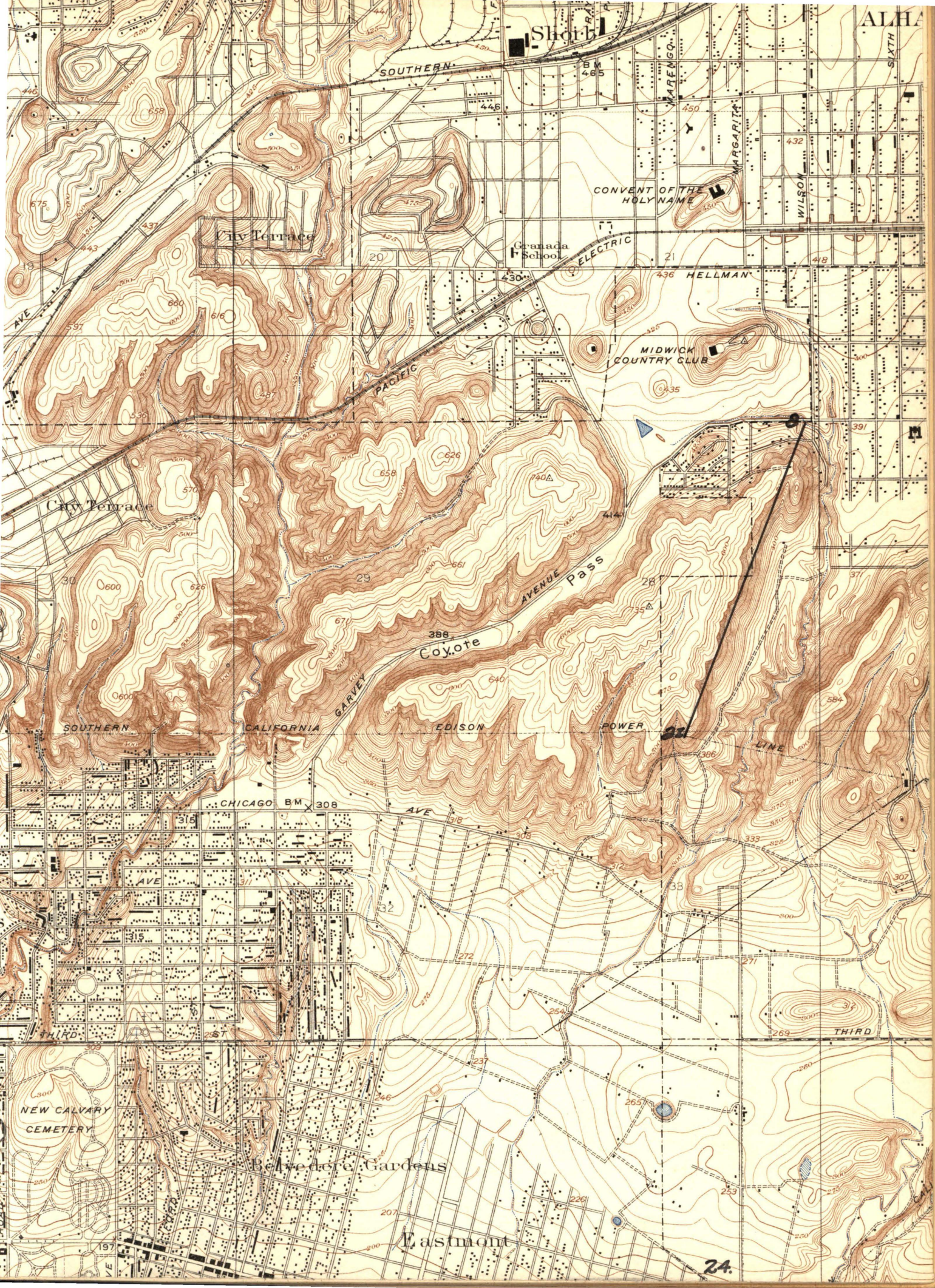
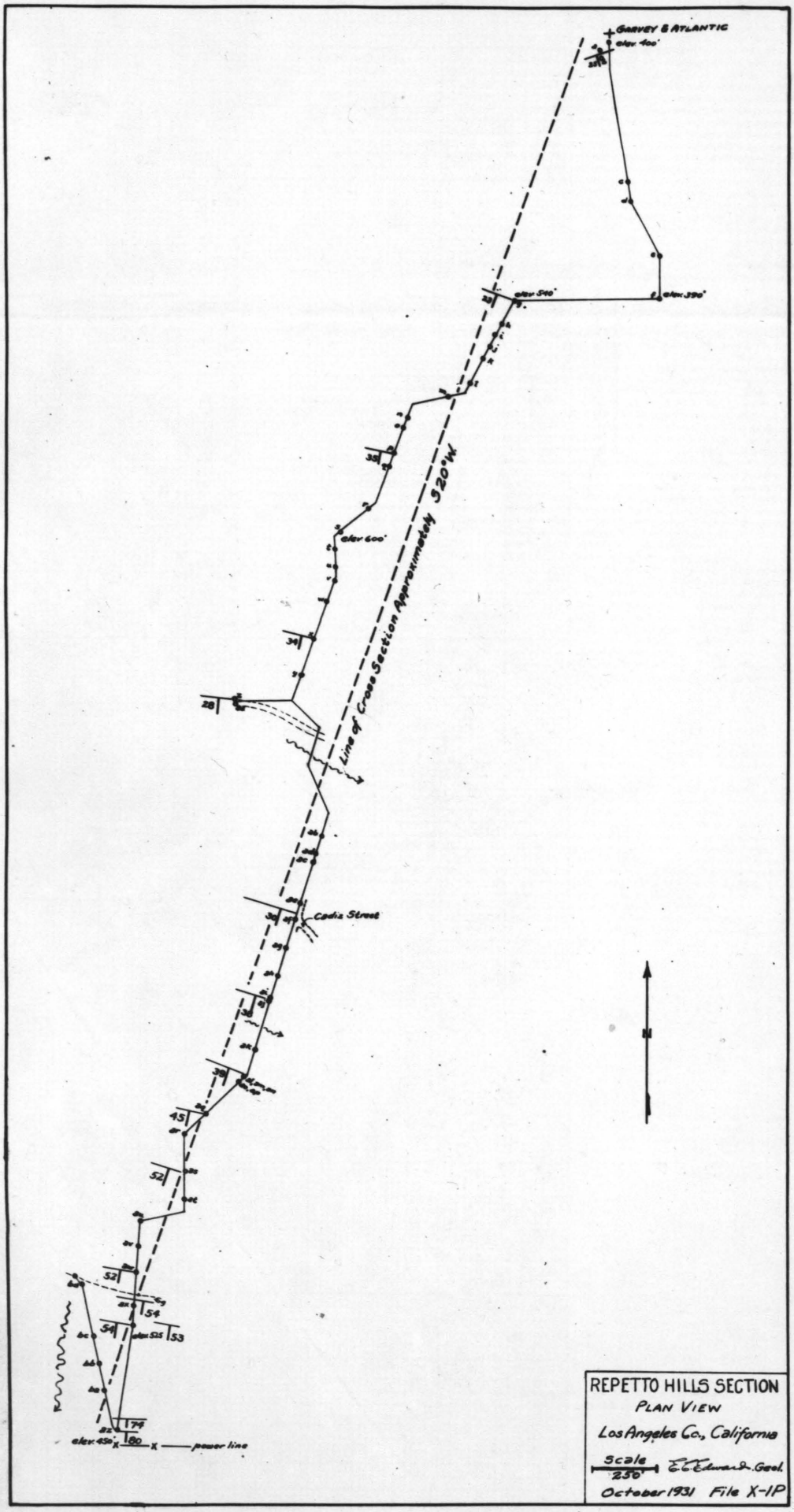
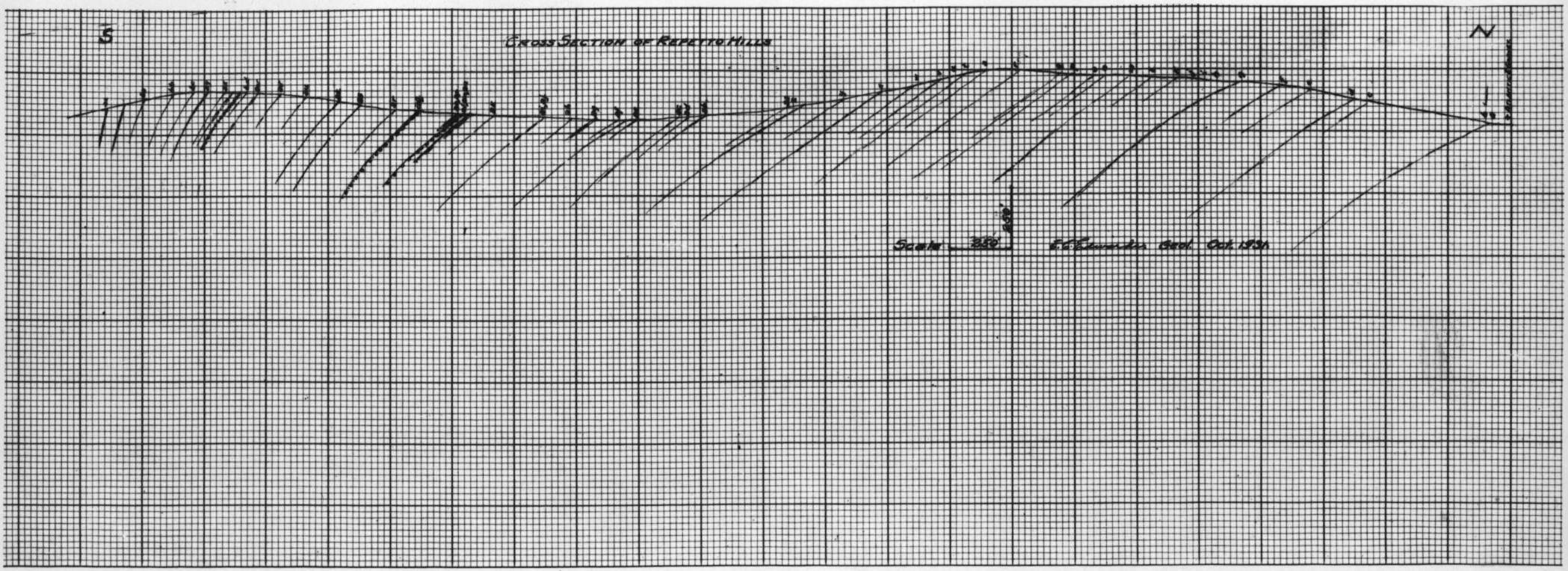

ALHA
Shorb
SOUTHERN
PACIFIC
ELECTRIC
BM 465
ARENGO
MARGARITA
SIXTH
WILSON
CONVENT OF THE HOLY NAME
City Terrace
Granada School
HELLMAN
MIDWICK COUNTRY CLUB
AVE
City Terrace
Pass
AVENUE
Coyote
GARVEY
SOUTHERN CALIFORNIA EDISON POWER LINE
CHICAGO BM X 308
AVE
AVE
THIRD
THIRD
NEW CALVARY CEMETERY
Belvedere Gardens
Eastmont
24.


GARVEY & ATLANTIC
elev 400'
elev 540'
elev 350'
Line of Cross Section Approximately 320°W
elev 600'
Cadiz Street
elev 525'
elev 450'
power line
N
REPETTO HILLS SECTION
PLAN VIEW
Los Angeles Co., California
Scale 250'
C.C. Edwards, Geol.
October 1931 File X-1P



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(3). Stewart, Roscoe E. and Katherine C., Post Miocene Foraminifera from the Ventura Quadrangle, Ventura County, California. Journal of Paleontology, Vol. 4, No. 1, March 1930.

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(7). Cushman, Joseph A., Stewart, Roscoe E. and Katherine C., Tertiary Foraminifera from Humbolt County, California, Transactions of the San Diego Society of Natural History, Vol. 4, No. 2, February 1930.

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(9). Contributions from the Cushman Laboratory, Vol. 1, Part 2, July 1925

(10). Contributions from the Cushman Laboratory, Vol. 3, Part 1, March 1927.

(11). Contributions from the Cushman Laboratory, Vol. 5, Part 4.

(12). Smithsonian Institution, U.S. National Museum, Bull. 71.

(13). Smithsonian Institution, U.S. National Museum, Bull. 104.

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