Hand-out At RMAG-UGA (Oct. 79)
Field Trip - Eastern Nevada

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AN EXTRUDED CRUST HYPOTHESIS
DEVELOPED FROM EVIDENCE IN THE PIOCHE DISTRICT, NEVADA

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ABSTRACT

Interpretation of exploration drilling, coupled with previously accepted geologic history, is believed to present strong evidence that the Pioche hills are what remains of a solid plug pushed up through great height in a relatively short period of time. Resultant sliding away of the elevated block has placed huge masses of formation, sometimes broken and sometimes quite solid in appearance, overlying the surrounding surface.

The mechanics involved in this hypothesis simply require that steep faulting was great in magnitude and that movement was too rapid for erosion to reduce the surface as elevation proceeded, thus requiring that elevated crust slide off to the surrounding surface.

Direct observation and surface mapping fail to reveal the true magnitude of movement bordering the mountain plug. Only the slide faults or at most a late component of adjustment on the large plug-forming faults can be observed.

It is postulated that if this hypothesis is correct for the Pioche hills, the same sequence of events could apply to many mountain ranges. Plugs of much greater area and vertical movement could account for horizontal forces sufficient to produce true thrust fault action a considerable distance from the plug. Large tilted blocks could likewise involve the same magnitude of vertical movements with resultant slide blocks. The suggestion is advanced that isostatic balance should play an important role and loading of areas around such plugs or tilted blocks could have perpetuated the extrusion of crust until stabilization was reached.

PREFACE & ACKNOWLEDGMENTS

This script is intended to present a hypothesis that seems to fit local conditions around Pioche, Nevada, and some nearby places with which I have been working for many years.

The "landslide" interpretation of drill hole information was first presented orally with the aid of charts and slides in a meeting of the Eastern Nevada Geological Society in January 1956.

The reader is asked to realize the limitations of my experience, which has been mostly limited to mine development and local exploration. Here is an attempt to use some of these local and detailed observations to reach conclusions that necessarily have regional implications. Boldness has been encouraged after lengthy discussions with men who are qualified by their experience to say whether the ideas have merit. I would not state that any of these qualified persons has given positive support to the expanded "Extruded Crust Hypothesis". But some of them readily accept the "slide fault" ("landslide") in lieu of "thrust fault" interpretation, others admit the possibility and all of them have contributed to the evolution of these thoughts through lively conversation. This script is not intended for publication, but is for distribution to those who are alraady familiar with the Pioche area and related geology. The objective is to generate sufficient interest in the hypothesis to undertake proof of its validity. Unfortunately, my time has been so limited by other activities that this presentation falls far short of being as thorough as I had intended it to be.

It would be impossible for me to list the many people to whom I am indebted for their interest. Perhaps the most helpful and lively discussions have been with C. F. Park, Jr., C. M. Tschanz, Hoover Makin, E. F. Cook and certainly the frequent discussions with my close associates in the area should be emphasized, particularly E. H. Snyder, Earl B. Young, R. G. Lee, S. S. Arentz and B. S. Hardie.

FORMER INTERPRETATIONS AND REASON FOR DOUBT

In the interest of simplicity and in view of completely inadequate time for the preparation of a thorough background of information, it is here considered sufficient to refer to Professional Paper 171 and some of the problems that have developed over the years leading to this suggested hypothesis. The Pioche formations embrace Cambrian units which are broadly grouped in ascending order as Lower and Middle Cambrian Prospect Mountain Quartzite, Pioche Shale, Lyndon Limestone, Chisholm Shale and Highland Peak limestones and dolomites overlain by Upper Cambrian Mendha limestones and dolomites. An old erosion surface separates upper members above mentioned from thick volcanic flows of Tertiary age. A most significant observation is that the attitude of sediments conforms quite closely with the attitude of associated flow rock in numerous exposures, whether dips are moderate or steep. This fact is in accordance with the geologic history as stated in Professional Paper 171 and outlined as follows:

Historical Summary

1. Sedimentation - Cambrian to Pennsylvanian
2. Uplift - slight warping - erosion
3. Volcanism - late mesozoic or early tertiary may have continued to span one or more faulting epochs
4. Tilting and normal faulting)In "Extruded Crust
5. Thrust Faulting)Hypothesis" These
6. Quartz Monzonite Intrusives - Blind Mountain)Events May Be Simul-
7. Normal Block Faulting - Basin and Range Type)taneous or Inter-
)Related
8. Erosion of Faulted Blocks to Essentially Topog. of Today
9. Outbursts of Volcanic Ash - Late Pliocene - Deposition Lake Beds
10. Meadow Valley Erosion - (Drain to Colorado River)

It is realized that elsewhere in Nevada, tectonic history includes events not covered in the above outline. But faulting is not in evidence that would account for observed relationships at Pioche and other places noted herein, except (1) through the geologic history as outlined which includes thrust faulting between different periods of normal faulting or (2) through steep normal faulting cut by flat normal faulting (slide faulting) in place of the thrust faulting.

Without the benefit of drill hole information from exploration work performed in 1955, the accepted interpretation of regional thrust faulting was open to some question because of the oft-repeated finding that the flat faulting identified as thrust movement accounts for cutting out large segments of formation - a normal relationship - except for locations involving flow rock beneath the "thrust" plate. The latter relationship could be explained by slide-off from the elevated mountain block. Without some strong evidence to support a tremendous magnitude of uplift, the thought was not considered tenable. So, reasoning followed, if faults bordering the Ely Range do not have vertical displacement of great magnitude and if flat faulting can be expected to cut out a large section of column (as postulated and later demonstrated by drilling on the east side of the Ely Range) the exploration potential should be good for continuation of a major "ore channel" on the West valley side of the range-front fault. For anyone not familiar with the Pioche ore bodies, suffice it to explain that the "ore channel" is a broad band of mineralization confined to the lower limestone member of Pioche shale. Thus, if range-front fault displacement could be demonstrated to be not too great, the Pioche shale with its limestone member favorable for ore deposition might be reached and explored for the continuation of a productive ore zone on the valley side of the range-front fault.

EXPLORATION DRILLING RESULTS

Accompanying Figure I has been sketched to approximate scale and shows the result of drill hole exploration. In this figure, it will be noted that a hole labeled C.D.H.36 penetrated Highland Peak Limestone with some mixed "lava" then went into a 150 ft. thick layer of clay which due to its tendency to squeeze into the hole, prevented the drill hole from penetrating the gouge zone. It was hoped that the presumed "thrust fault" represented by this thick clay zone would be underlain by Cambrian sediments and that sufficient of the geologic column would be absent to place the favorable "C. M. Bed" at reasonable depth. After the churn drill failed to penetrate the gouge and reveal what was below, a rotary drill was employed which penetrated the gouge zone, then went into solid flow rock that was readily identified as a typical member of the thick flows exposed in Condor Canyon and described in Professional Paper 171. The fresh appearance of cuttings and uniform hardness reported by the drillers gave convincing evidence of the unbroken nature of this flow rock contrasted with the badly fractured and broken ground overlying the gouge zone. The hole remained in uniform flow rock to depth of 2450 feet which gave proof that the sought-for ore horizon would be far too deep for exploration. Figure I is a possible interpretation which assumes the flow rock penetrated by the drill hole rests on the old erosion surface at about the top of Cambrian sediments. The erosion surface is placed by crude interpolation at the top of Mendha Limestone.

Thus, according to the hypothesis, the so-called "Frontal Fault" has in excess of 10,000 feet of vertical displacement. If the lavas (ignimbrites) encountered below the thick clay gouge also constitute crust that has slid from the elevated plug, overall elevation of the Ely range block could be much more than here suggested.

IMPLICATIONS

If the Historical Summary is correct as above shown without any involvement with regional thrust faults and if the thick flows are known to have spread over a given area, then steep faulting that places Prospect Mountain Quartzite, for example, on the top of a range must be credited with vertical displacement sufficient to account for all sediments known to have been below the old erosion surface, plus all the thickness of surface flows plus any "landslide" or slide-fault blocks overlying the flows plus more recent lake beds and alluvium plus the height of the mountain to which the quartzite has been elevated above the present valley floor.

In application of the hypothesis, the field observer must bear in mind that slide blocks must follow in succession as the rising block progresses. Obviously, the true magnitude of the concealed fault is never apparent by measurement across a presently exposed fault plane which will be either a slide fault itself or a late break-through component of movement on the large, deep seated fault (or fault zone).

Possible implications are best shown by citing specific locations and field evidence that can be explained by the hypothesis as, for example, the following:

(1) Progressing north and west from Pioche, the erosion surface on which lava rests is found to become higher in the sedimentary series. Arizona Peak, east of Stampede Gap can be interpreted as a slide block from the top of Highland or the south end of Bristol Range. And the Ely Springs range can likewise be a Westward displacement from above the Highland Range. If this be true, Ely Springs range rests on the thick flows.

(2) Near Caliente, at Anteloupe Canyon, Prospect Mountain quartzite is found steeply tilted to the east. At the canyon mouth, conformable Pioche shale is found, in turn overlain by Lyndon Limestone rubble faulted against flow rock rubble. Applying the slide-off conception, it appears the volcanics slid to the Southeast while the missing sediments between Lyndon and the flows may be accounted for in hills to the west from the Chief Range.

(3) Patterson Mountain, some 50 miles north of Pioche illustrates a location that requires much greater vertical movement than the Ely range because Carboniferous sediments were present under the thick surface flows as evidenced by nearby exposures. In 1946, drill holes at the Walker Tungsten Mine (Cinch Tungsten) encountered flow rock under limestones that have been interpreted to belong higher than exposed formations on the mountain. Here, both the higher limestones and the flows encountered under them in 300 ft. holes may be interpreted to have slid from Patterson Mountain. The required vertical displacement to place quartzite on top of Patterson calculates more than 25,000 feet.

(4) At Conners' Pass, south end of Egan range, repetition of White Pine shale by thrust faulting has been described. Here, the known presence of Prospect Mountain quartzite on high peaks north of the pass suggests the possibility that recurrent elevation and sliding could cause repetition of formations. In such cases, early planes of weakness on which the first slides rest would be presumed to offer sufficient resistance to cause pile-up of succeeding slides rather than recurrent slides pushing earlier blocks away from the front.

(5) Remnants of sliding crust caused by gravity should be in evidence many places where at least portions of the slide blocks are still resting on the "core" ranges. Examples of this would include all locations where the slide faulting can be assumed to account for missing formation (a normal relationship) and the slide block has not crossed the hidden frontal fault onto flow rock. Examples that illustrate this situation are (a) the east side of Ely range, south east from Pioche, where exposed formations that could have slid from the quartzite hills forming the range core are in normal relationship to underlying formations and (b) the "thrust" plate situated northwest from the Bristol Mine where ordovician rests on Middle Cambrian and (c) the hill just west of Stampede Gap between Highland and Bristol ranges. The latter location is believed to be an excellent type locality which shows rotation and thinning of formation sequence above Chisholm Shale yet under the main slide (or thrust) fault as mapped on plate 1, Professional Paper 171. This location also typifies the commonly observed slippage within the Chisholm Shale (siltstone) horizon which evidently acts as a zone of weakness and lubricant for movement of large blocks of ground.

(6) South of Mt. Wheeler and Mt. Washington in the Snake range, dips are to the south and flat faulting could be assigned to gravitational forces. Here, as one would expect, flat fault structures in Lower and Middle Cambrian sediments appear to be of lesser magnitude than in higher formations. Greater distortions with steep bedding dips are in evidence in the younger formations as on Mt. Lincoln.

POSSIBLE FORCES FOR PERPETUATION OF SOLID EXTRUSION

Forces to perpetuate the movement may have been generated by loading the surface surrounding the plug (or tilted block) with heavy crust. Transfer of lighter-weight fluids to the rising block would keep the system out of isostatic balance until lighter-weight, rising, segregated magma became exhausted. At that time, the sinking, or loaded blocks would come to rest with their roots in more basic, heavier fluids, or magma from which the more volatile and lighter weight fractions had been separated.

CLOSING COMMENTS

Slippage of crust over flat surfaces, lubricated by internal pressures in clay or gouge has been postulated and described by Huobert & Ruby (See GSA Bul. Feb. 1959). It is noteworthy that drill holes in Figure I did encounter a great thickness of clay gouge that squeezed into the hole. The rotary drill overcame this difficulty by use of a mud-filled hole creating a back pressure. This clay is bentonitic and is an alteration of flow rock.

To anyone considering the acceptability of the Extruded Crust Hypothesis to any given set of conditions, emphasis is directed to the possible large dimensions of displaced blocks. Perhaps, deep exploration holes would still fail to penetrate through the displaced crust and into underlying sequence of flows plus complete sequence of sediments in turn underlying the flows.

EXTENSION OF REMARKS ON "AN EXTRUDED CRUST HYPOTHESIS"

By Paul Gemmill

November 1964

The foregoing script has been copied and duplicated for presentation to interested persons at a luncheon meeting of A.I.M.E. on November 13, 1964 in Reno, Nevada. With this opportunity, some additional comments are herewith presented.

First, attention is drawn to the sketch headed "MONOCLINAL STRUCTURE". This shows idealized interpretation of typical "Domino" and "Card Deck" exposures noted in the field.

Second, it is most significant that the concept of gravity forces accounting for major flat crustal movements of the type here described is strongly supported by a recognized authority on southwestern Utah. Quoting J. Hoover Mackin (1) "It is stated as a deliberately provocative working hypothesis that block faulting has been the only type of regional teconism in the Great Basin in post-orogenic time." And Charles M. Tschanz (2) recognizes gravity sliding as a likely interpretation for the flat faulting he describes in northern Lincoln County. Dean Earl F. Cook has contributed much valuable evidence with his ignimbrite flow studies and their utility in dating fault movements.

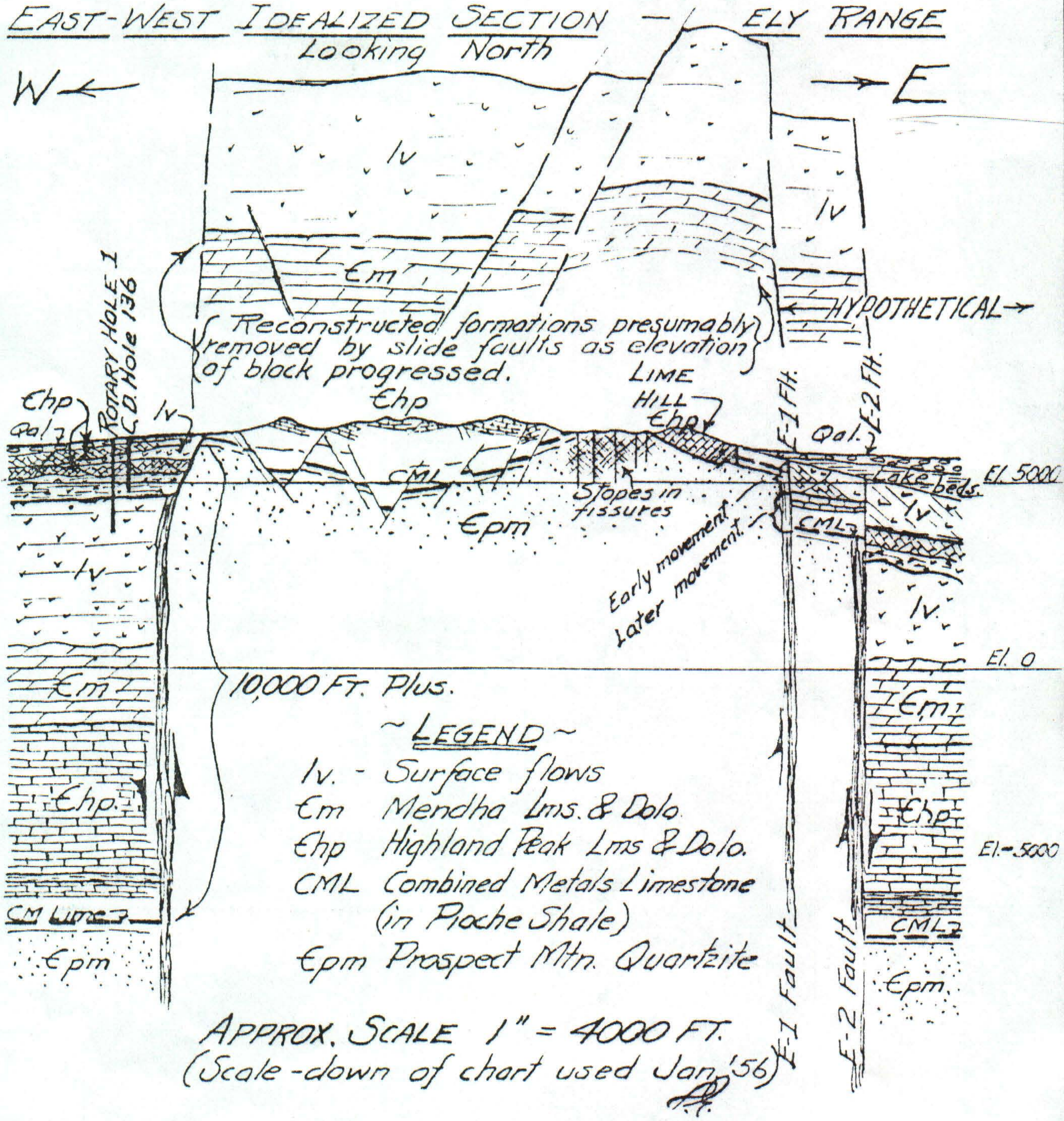
Finally, the large monoclinal blocks of hard rock, both limestones and flows that form thick horizons of fractured crust above the old flow rock surface yet beneath the late Pliocene and younger lake beds may constitute permeable oil reservoir material where buried deep enough to maintain the necessary temperatures for Nevada's high pour point oil. And, these same fractured horizons are suggested as likely aquifers for the deep migration of ground waters.

(1) Structural Significance of Tertiary Volcanic Rocks in Southwestern Utah
By J. Hoover Mackin
American Journal of Science, Volume 258, February 1960

(2) Geology of Northern Lincoln County, Nevada
By Charles M. Tschanz, U.S.G.S., Menlo Park, California
Eleventh Annual Field Conference - 1960

EAST-WEST IDEALIZED SECTION — ELY RANGE

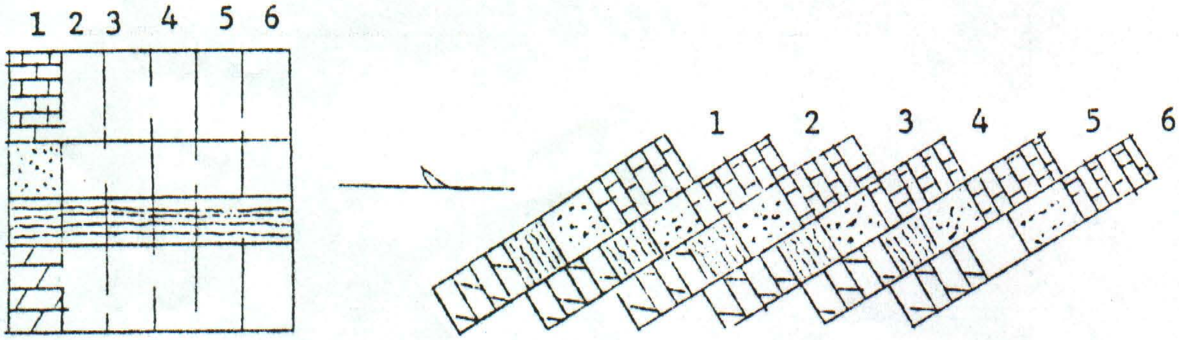
Looking North



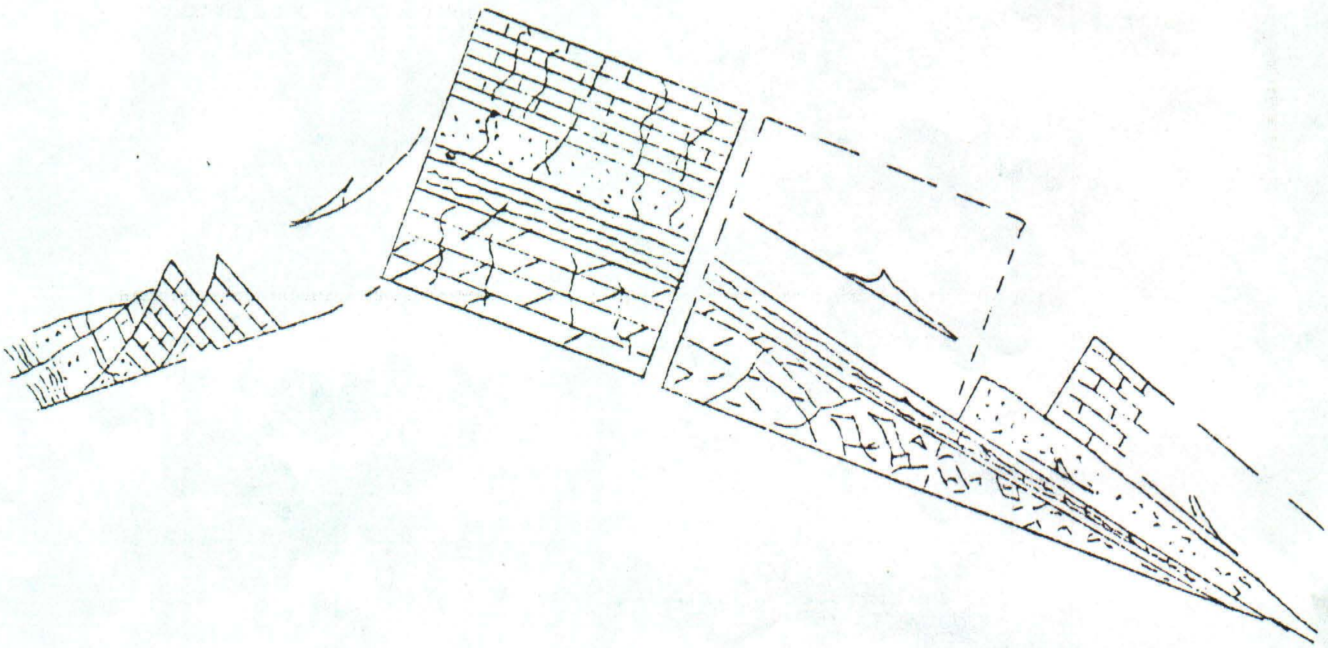
NOTE — On the east side, a large block of CML — Pioche Shale, interpreted to be like the one above shown between hypothetical faults E-1 & E-2 has been proven by drill holes. It is not known whether the relationship is as here shown or whether the alternate likely possibility of a single large fault (E-1) caused the CM. Lms. block to slide over flow rock. (The latter would greatly decrease prospect for ore deposition in the "CM. bed" by mineralization that is known to be later than the slide faulting.)

M O N O C L I N A L   S T R U C T U R E

TYPICAL OF THE PIOCHE, NEVADA DISTRICT AND OF THE SURROUNDING REGION



(1) "DOMINO" OR "VENETIAN BLIND" (Mackin) STRUCTURE.



(2) "DOMINO" (left) or "CARD DECK" (right) STRUCTURE AND SUGGESTED MODE OF ORIGIN FROM ELEVATED BLOCKS