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XII C

EMPLACEMENT OF PLUTONIC INTRUSIONS IN THE SIERRA NEVADA WEST OF SEQUOIA NATIONAL PARK

G.S.A. Bull. v. 50, p. 1945
Berkeley.
Aug. 39

BY CORDELL DURRELL *

Roof pendants of schist are embedded in plutonic bodies which range in composition from gabbro to granite. Individual plutonic masses average about 15 square miles in area.

The roof pendants, up to 15 miles in length, are exceedingly irregular in outline, with steeply dipping walls and nearly flat floors which are exposed in many places. Internal folds, both anticlines and synclines, are mappable and behave in a normal manner.

A zone of dike injection at the edges of the roof pendants passes into a zone of inclusions in the plutonic bodies. The plutonic bodies everywhere dip beneath the wall rocks.

Fold axes and thick sections of metamorphosed bedded rocks are truncated at intrusive contacts, and evidence of large-scale dislocation of wall rocks by plutonic bodies is totally lacking. Protoclastic structures in the plutonic rocks are also completely absent. Antistress minerals are found everywhere in the contact-metamorphosed facies of the roof pendants.

Migmatites, injection gneisses, and plutonic breccias occur locally along the contacts.

These data seem to require a passive mode of emplacement, and piecemeal stoping seems to have been the method operative at least in the later stages of consolidation. The method of opening of the magma chambers at an earlier stage may have been through assimilation. This is indicated by the local injection gneisses and by the general absence of stoped blocks in the central areas of the plutonic bodies. Evidently forceful injection played no part in intrusion.

XN C

GSA B. 63 (52) p. 1359

GRANITIZATION IN THE SIERRA BATHOLITH AT MT. WHITNEY, CALIFORNIA

Charles C. Bradley

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A study of the publications on the Sierra batholith shows that, while this granite body is cited as an example of a typical plutonic complex, many of the writers have not been completely satisfied with the theory of magmatic differentiation as the unique solution to the problem of petrogenesis.

Petrographic evidence collected in the vicinity of Mt. Whitney indicates that, at the very least, one-fourth of the bulk of the granite of this area has been derived from pre-existing metamorphic rocks, that the mineral alterations followed in part a base-exchange pattern whereby andesine and biotite were altered to oligoclase, hornblende, and orthoclase, and finally that, while potash and soda traveled with a mobile or liquid fraction, other changes seemed to have been accomplished under solid or mushy conditions.

Albitic metacrysts which occur in the metamorphic border rocks survived the granitization process and are found, in somewhat reduced numbers, in the granite. Their relative abundance is used as a clue to the quantity of metamorphic rock altered to granite. Evidence for other mineral changes lies in the identification of certain mineral features which are interpreted as vestiges of reactions which did not go to completion.

A theory of cellular origin for the spectacular orthoclase metacrysts of the Cathedral Peak granite is presented.

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XIIC

ISOSTATIC COMPENSATION FOR THE SIERRA NEVADA, CALIFORNIA

GSA Bull. v. 67 (1956) p. 1724

Howard W. Oliver
U. S. Geological Survey, Washington 25, D. C.

During the summers of 1951, 1952, and 1956, about 1500 gravity stations were occupied in a 13,000-square-mile area of the Sierra Nevada, extending 120 miles north and south of the Mt. Whitney region. Complete Bouguer anomaly values range from −20 mgal at the western edge of the Sierra to a minimum of −250 mgal just west of the Sierra crest, a distance of only 65 miles. Other studies show that, farther eastward, a positive regional gradient of 1 mgal per mile continues at least as far as Death Valley. The form of this west-to-east Bouguer anomaly profile persists all along the strike of the Sierra; the maximum anomaly relief of 230 mgal is midway between Sequoia and Yosemite national parks. The anomaly relief drops off much more rapidly to the south than to the north; Bouguer anomaly values in the Bakersfield-Inyokern profile range from −40 mgal to −140 mgal, so the anomaly relief is only 100 mgal.

Isostatic anomalies corrected for local geologic effects are very close to zero at the western edge of the Sierra Nevada. The central and eastern Sierra regions are overcompensated by 40–50 mgal, suggesting that current uplift along the Sierra Nevada fault zone may be caused by isostatic forces. However, there is no local isostatic response to the 10,000-foot eastern scarp. Gravity determinations of the thickness of the earth's crust are in general agreement with seismological work in the Sierra Nevada by Byerly, Gutenberg, and Press.

XII c

STRUCTURAL SURVEY OF THE GRANODIORITE SOUTH OF MARIPOSA, CALIFORNIA.

Ernst Cloos.

American Journal of Science, April, 1932.

South of Mariposa the Mother Lode zone is terminated by a large offshoot of granodiorite, extending westward from the main mass of the Sierra Nevada batholith. There is a pronounced structural difference between the granodiorite of the main mass and the Mariposa intrusion. The latter shows a distinct flow-structure, by the parallelism of mica and hornblende crystals, the parallelism of dark inclusions (basic clots and autoliths, and xenoliths) and the orientation of swarms of inclusions, schlieren and segregations. The parallelism is either linear (produced by elements with one long and two short axes, as hornblende needls and spindle-shaped inclusions,) or platy, produced by elements with two approximately equal and one appreciably shorter axis, as mica crystals or pancake-like inclusions. However, rock exposures without any distinct structure, or with equi-dimensional inclusions, are also common. The linear parallelism prevails in the western portion, but on approaching the east contact of the Mariposa intrusion, a platy parallelism of the minerals becomes more and more conspicuous.

The main batholith (east of Mariposa) shows an intense foliation and linear parallelism of the minerals (flow-lines) within the foliation planes. The dark inclusions are elongated and appear as thin sheets of dark material, in regular order and perfect parallelism, like gneisses in certain places. This is most pronounced along the contact.

Method of Structural Survey. (Hand Cloos.) This consists in recording and measuring systematically the distribution, mutual relations and orientation of all structural features or "elements", in so far as they resulted from the intrusion and incipient consolidation of the igneous rock.

Structural Elements of the Mariposa Intrusion.

I. Elements of the Viscous Phase.
  1. Linear Structures.
    a. Parallelism of needle-shaped crystals. (Hornblende.)
    b. " " spindle-shaped inclusions. (Autoliths or xenoliths.)
    c. Schlieren of linear elongation.
    d. Chain-like swarms of inclusions of all kinds.

  2. Platy Structures.
    a. Parallelism of crystals of discoid shape (Mica.)
    b. " " inclusions of discoid shape.
    c. Platy schlieren.

II. Elements of the Closing Viscous and Incipient Solid Stage.
  1. Schlieren-like primary flexures.
  2. Primordial faults, filled with dike material.

III. Elements of the Solid Stage.
  1. Early joints filled with aplite, pegmatite or basic dikes.
  2. Primary or early barren joints.

The orientation of these elements was measured with a compass and clinometer, and plotted on the map and in the block diagram.

Structure Elements of the Stage of Viscosity along the Contacts. There are two types of contacts. (1). Between the granodiorite and the wall rocks, the Calaveras and Mariposa formations. This type of contact is sharp. (2). The contact between the Mariposa intrusion and the main mass of the Sierra Nevada batholith. This type is gradational.

The contact of the Mariposa intrusion follows the structure of the surrounding country rock almost everywhere. The normal regional trend of all rocks along the western slope of the Sierra Nevada is NW-SE. The rocks have been locally bent out of their normal direction, and the granodiorite which occupies the space between the distorted walls is inserted concordantly, intruding between the slates and schist layers rather than cutting across them.

The contact between the main Sierra Nevada batholith and the Mariposa intrusion is represented by a shear-zone of the closing stage of viscosity, indicating intense movements. The difference between the rocks on opposite sides of the contact zone lies in the intensity of the flow-structures and their orientation, which differs up to 90°.

Approaching the contact, the granodiorite of the main mass shows signs of pressure and primary movements by increasingly intense flow-structures. This "inner contact zone" does not everywhere follow the granodiorite-schist boundary. It leaves the boundary 5 miles SE of Mariposa, where the schist salient swerves to the west, and the pressure zone continues SE clear across the granodiorite, separating the main mass from the Mariposa intrusive. This pressure zone is the SE extension of the Mother Lode zone in general, and can be traced into the granodiorite for miles. It shows a rigorous orientation of the structural elements, such as cleavage, flow-lines, inclusions, many dikes, flexures and faults.

On approaching this zone from the Mariposa intrusion on the west, the flow-structure, which, so far, strikes E-W, bends within a few hundred yards into the NW-SE direction of the pressure zone. Platy elemnts become more and more important; they are joined by cleavage planes; and flow-lines, strike faults, cross faults and flexures appear. The zone is about half a mile wide. The grnodiorite of the east side is more strongly foliated than is the rock on the west, and its parallelism follows the general NW-SE direction. Inclusions, cleavage and linear parallelism dip steeply east or stand vertical.

Flexures and faults in the pressure zone dip west, at 50°-70°. Filled with pegmatite and aplite, they represent movements during the close of the viscous stage. Cleavage planes are bent into their directions. The boundaries of the flexures and faults are not clean-cut, but schlieren-like, and show a distinct drag. Mica crystals are turned out of their normal position into parallelism with the faults and flexures. To judge from the drag along the faults and flexure zones, the east block has been uplifted with reference to the west block, i.e. the main mass has been uplifted with reference to the Mariposa intrusion.

Steeply-dipping cross-faults are abundant, and the displacements along them indicate that the N block moved NW with reference to the SW block. The movements along each one of these planes rarely exceed a few inches.

Internal Structure of the Mariposa Intrusion. The arrangement of the flow-structures within the intrusive depends entirely on the form of the space which was available for the intrusion. The elements are oriented parallel to the contact planes. The planes of mineral parallelism fol-

low the contacts in strike and dip, and the flow-lines coincide with the dip of the contact planes. The intensity of the flow structures in the granodiorite does not increase on approaching the contact.

The structures of the rock enable us to reconstruct in part the shape of the body. Its roots are to be sought in the east, near the contact with the main mass. From here a salient of the granodiorite has protruded into the country rock, using a gap which has been widened, if not opened, from the NE toward the S. What seems to be the Calaveras formation appears to have been bent out of its normal direction and split in two by the granodiorite.

A horizontal section through the body one half mile below the present surface would probably cut no more than half the outcropping area of the grnodiorite.

Structure Elements of the Solid Stage. Early joints and fissures, filled with silicic dike material, are most important in the N and E part of the Mariposa intrusion. Here are many aplite and pegmatite dikes, dipping 30°-50° SW. Barren joints, following the same direction, disregard the contacts. and can be seen in the adjacent wall-rocks.

No such dikes and joints have been found in the SW half of the intrusion.

These are feather joints and shear joints, caused by the relative displacement of two blocks. Here, these joints and dikes seem to have developed in response to the upward movement of the magma, which is recorded by the steeply-dipping flow-structures along the NE contact of the Mariposa intrusion.

The restriction of these fissures to the NE, and their absence from the SW portion of the intrusion is natural because in the SW the horizontal component of the magma movement equals, or predominates over, the vertical component.

Summary. The W contact of the Mariposa intrusion dips under that body, while the W contact of the main mass of grnodiorite dips steeply east or stands mainly vertical.

Well developed primary flow-structures record the direction of flowage in the Mariposa intrusive. The body was protected against regional influences by a thin wedge of metamorphosed sediments, and has therefore attained a structural independence of its own. The orientation of the flow-structure depends entirely upon the form of the space which was available for the intruding mass. As that wedge, or roof-pendant of metamorphic rocks forms the SE end of the Mother Lode zone, the Mariposa intrusion crosses the Mother Lode zone in the gap through which it is connected to the main mass.

A series of primary flexures and faults indicates block movements in the hardening magma, exactly in the continuation of the Mother Lode zone. Well-defined structures are developed in the same zone, cleavage planes, a strong foliation and parallelism of primary elements, and linear elongation. Flexures and faults are partly filled with dikes, proving their early age. The relative upward movement continued for a short time after solidification of the Mariposa intrusion.

Primary feather joints or shear joints were also filled with dikes and so inidicate the continuation of movements into the solid phase. Joints in the same direction in the wall rock show that the walls of the grano-

diorite were distended by the intruding mass, while the latter grew increasingly rigid.

There are no through-going faults, or upthrusts, like the main upthrusts in the Mother Lode zone farther NW. Hence the main movements along that zone have taken place before final fixation of the granodiorite, and perhaps even while the latter was more or less plastic. On the other hand, traces of very early movements along this zone are obvious.

Hence it is thought that the Mother Lode zone has originated in the period between the beginning of the granodiorite intrusion and its final consolidation. The intrusion of the granite batholith seems to be responsible for it.

The W contact of the Sierra Nevada batholith never dips W. Both contact zone and internal structures of the batholith stand vertical or dip east into the granodiorite. This does not corroborate the conception of a growth and enlargement of the batholith mass by replacement of older rocks in place.

References. (No details given.)

Bulletin G.S.A. Vol.45, No.5.877.
Journal of Geology. Vol.33.755.

XII C

To Ed Wisser
With the writer's best wishes

MESOZOIC GEOLOGY OF THE RITTER REGION SIERRA NEVADA, CALIFORNIA

HOMER D. ERWIN

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ANGELES.

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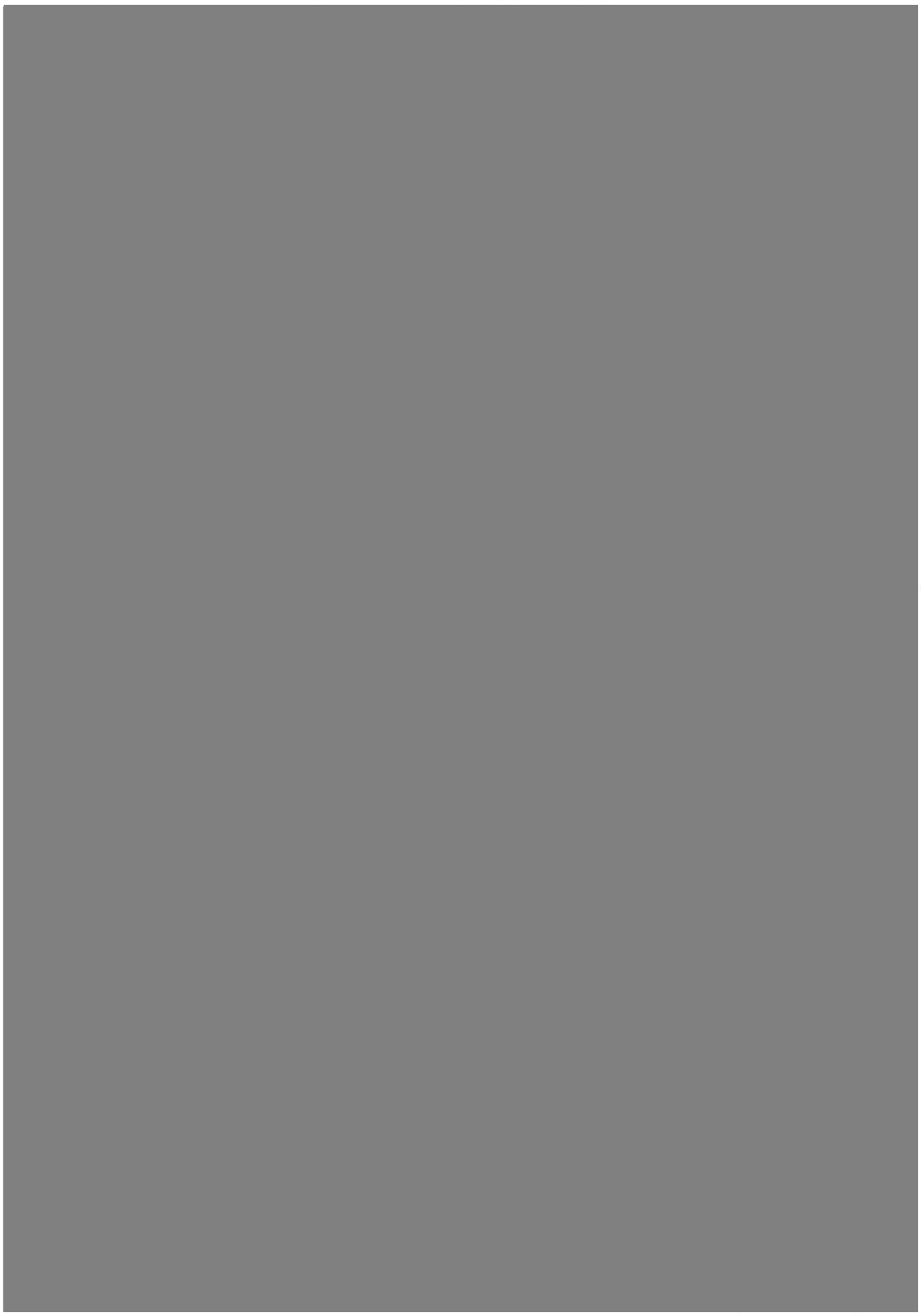
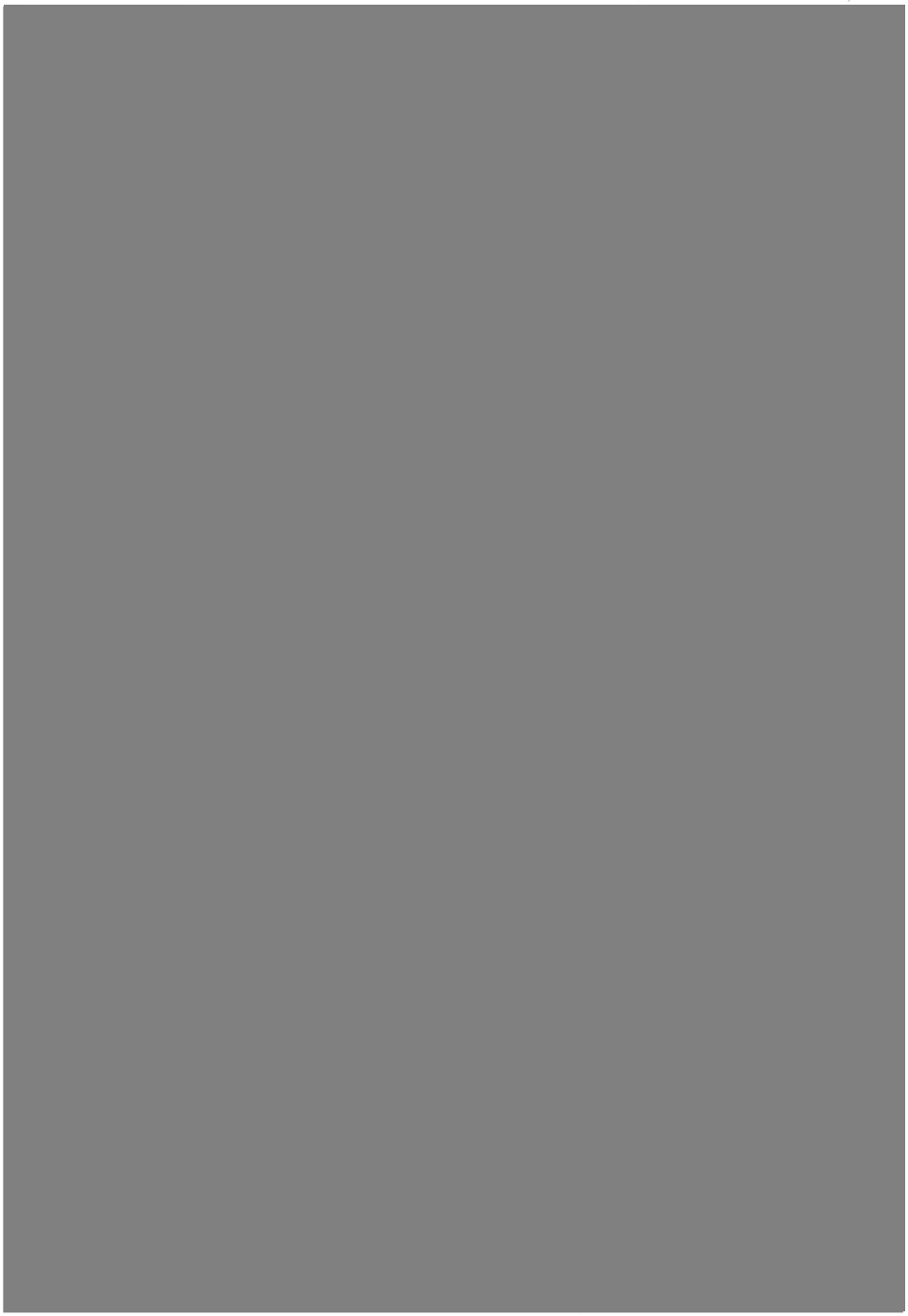
MESOZOIC GEOLOGY OF THE RITTER REGION SIERRA NEVADA, CALIFORNIA

HOMER D. ERWIN
Los Angeles, California

ABSTRACT

[redacted]





Date-?

GSA vol. 50 (1939) p. 1955

HISTORY OF FAULTING MOVEMENTS AT THE EAST FRONT OF THE SIERRA NEVADA, AS INDICATED BY DISLOCATED MORAINES

BY F. E. MATTHES

[redacted]

STRUCTURAL PROBLEMS IN THE SIERRA REGION

vol. 50 (1939) p. 1955-6

BY EVANS B. MAYO

[redacted]

XII C

SIERRA NEVADA BATHOLITH

MISC. NOTES FROM CLOOS LECTURES.

Intrusive complex,not a single batholith. Cross-section at Yosemite, 7 intrusions recognized,with in most cases time interval between intrusions long enough so that a later intrusion could break off and swallow consolidated chunks of an adjacent earlier intrusion..Although in at least 1 case an intrusion came up each wall of an earlier one,in general oldest intrusions are on W,and they are successively younger going east.

While E boundary of Sierra as a whole strikes NW,individual faults along it strike N-S;and while these faults are of Basin and Range age (late Teriary-Pleistocene),individual igneous massives tend to strike N-S.

(Calif.geologists assign an age to the batholith toward end of Jurassic. Isotope age determinations from rock specimens give it about 100,000,000 years,which is roughly Mid-K. Cloos says that No.7 intrusion cannot be distinguished from granitic rockd of the Baja Calif.,British Columbia and intermediate batholiths. Hence isotope determinetauons should be correlated with areal geology. Not impossible that intrusion going on here from latter Jurassic to Mid-K,~~xxxxx~~ but in such case intrusion continued long after sharp folding,when Sierra Nevada region had long been incorporated into the Cordilleran geanticline).Post-tectonic intrusion,like Idaho batholith. Some in Appalachians are syntextonic).

It follows that the crust had to accomodate,at a given time,not the whole great batholith but relatively small portions of it,arranged dike-like N-S.

Mother Lode reverse fault zone,which probably steepens with depth,is the mechanical SW boundary of the complex pluton. General plunge of the pluton to NW. Mother lode toward NW is higher with respect to the pluton than to SE More gold to NW.

Synteetonic plutons are commonly concordant.Post-tectonic plutons or those in stable areas (cratons) are discordant entering zones of weakness, crustal flaws, fissures etc.. African shield, plutons came into fault troughs.

Levels of Intrusion and Extrusion

Volcanic: Volcanoes. Fissure eruptions,Extrusives,but necks and dikes are intrusive. No space problem. Yellowstone cider cones.Mt.Lassen. Columbia Plateau. No ore deposits except perhaps Hg?

Sub-volcanic:Mass does not reach surface but close enough to surface to lift superincumbemt rocks.Spreads laterally as laccolith;both concordant and discordant. Dikes, sills. La Plata. Black Hills; Henry Mts.,Little Belt Mts.,Highwood Mts.,Montana.Sparse ore deposits.Contact metamirphism local.

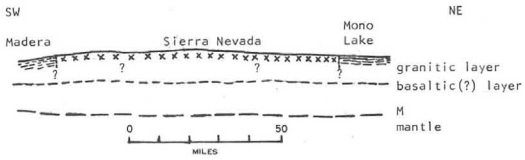
Upper Plutonic: Concordant and discordant large masses.Major batholiths. Isolated stocks.Abundant ore deposits. Fill tectonic spaces.

Lower Plutonic:Concordant masses,syntectonic.~~Injection gneisses of Front Range Range.~~ Ba;timore gabbro.

Migmatite Level: Mixing of magmas in lower crust;strong recrystallization, addition of material. Concordant. Wissahickon schist,SE US.Piedmont.Front Range.

XII C

BATHOLITH CROSS-SECTIONS



With best regards and thanks E. Cloos

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Beil.-Bd. 76. Abt. B. 1936. S. 355—450.

Margret Cloos gewidmet.

XII C

Der Sierra-Nevada-Pluton in Californien.

Von

Ernst Cloos,

The Johns Hopkins University, Baltimore Md.

Mit 3 Tabellen im Text, Tafel XV—XIX, 35 Abbildungen im Text, auf 4 Textbeilagen und auf Tafel XX—XXVIII.

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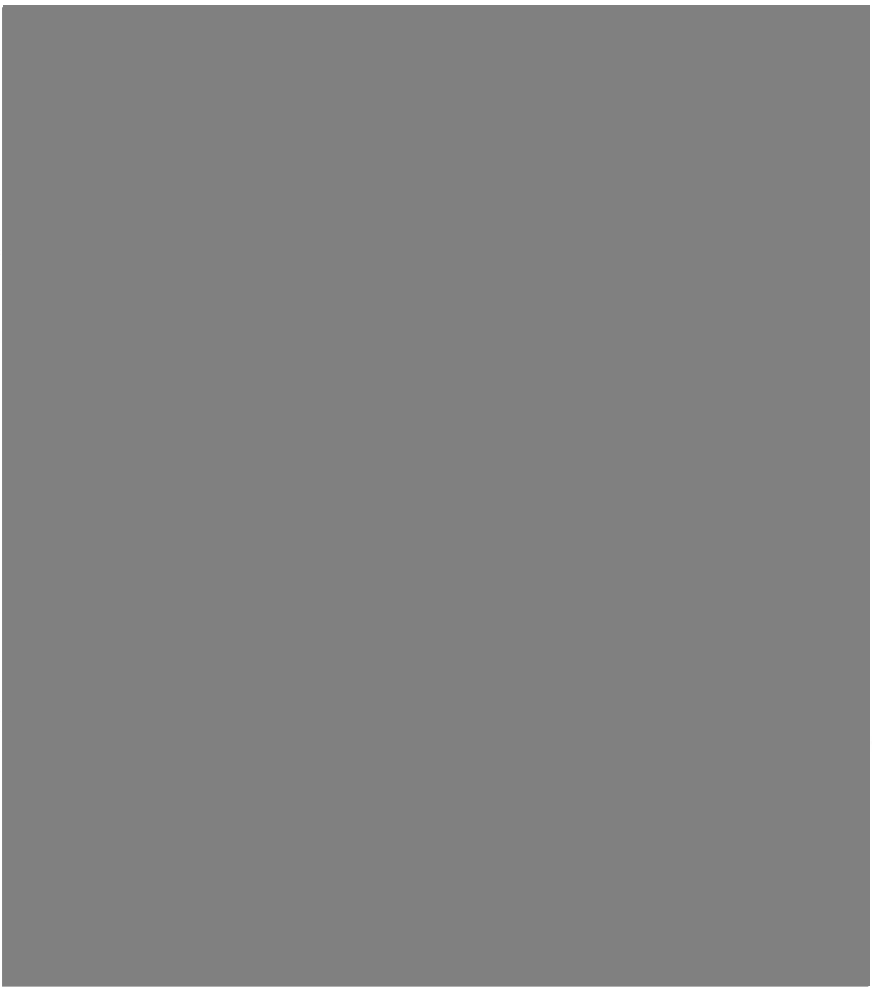
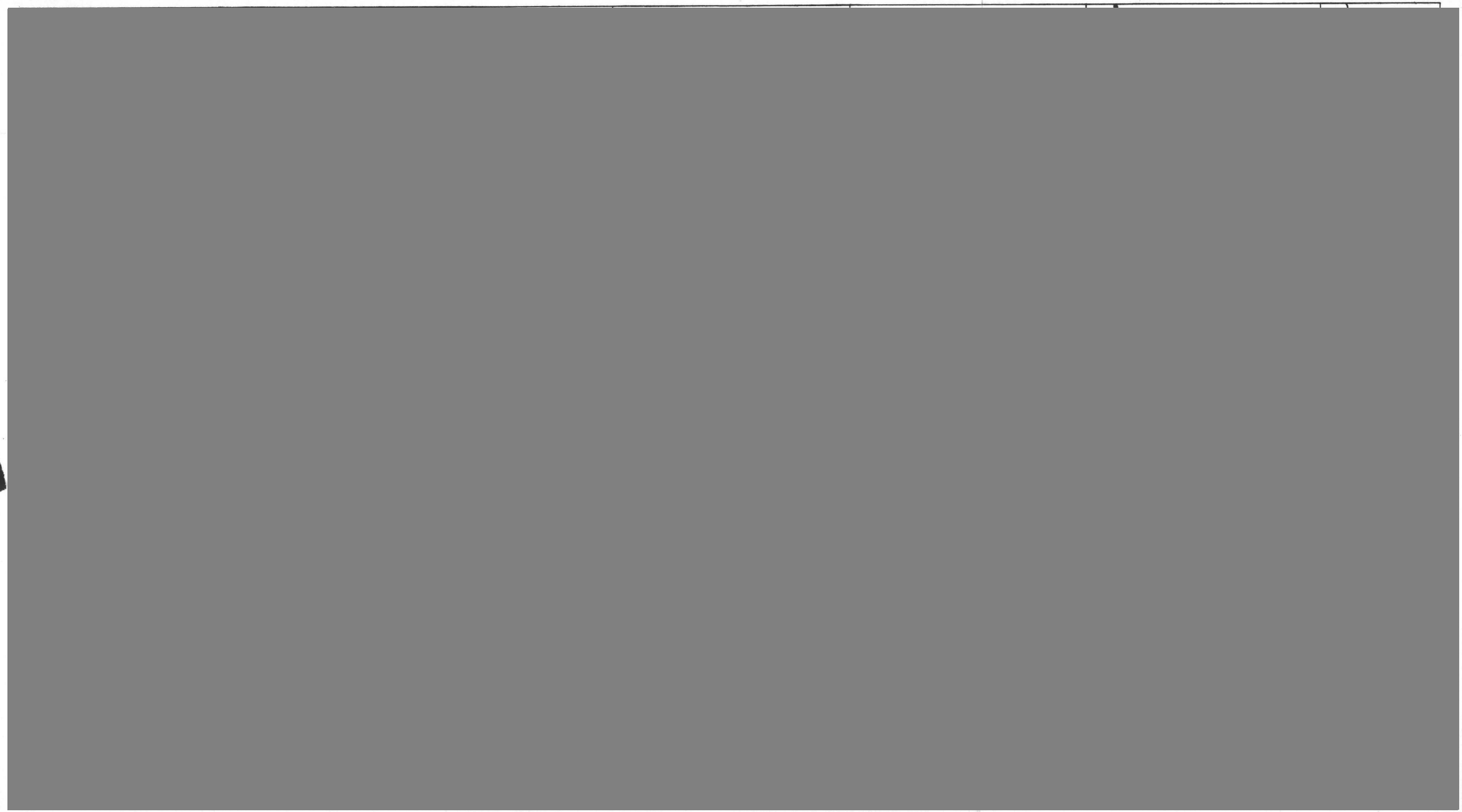
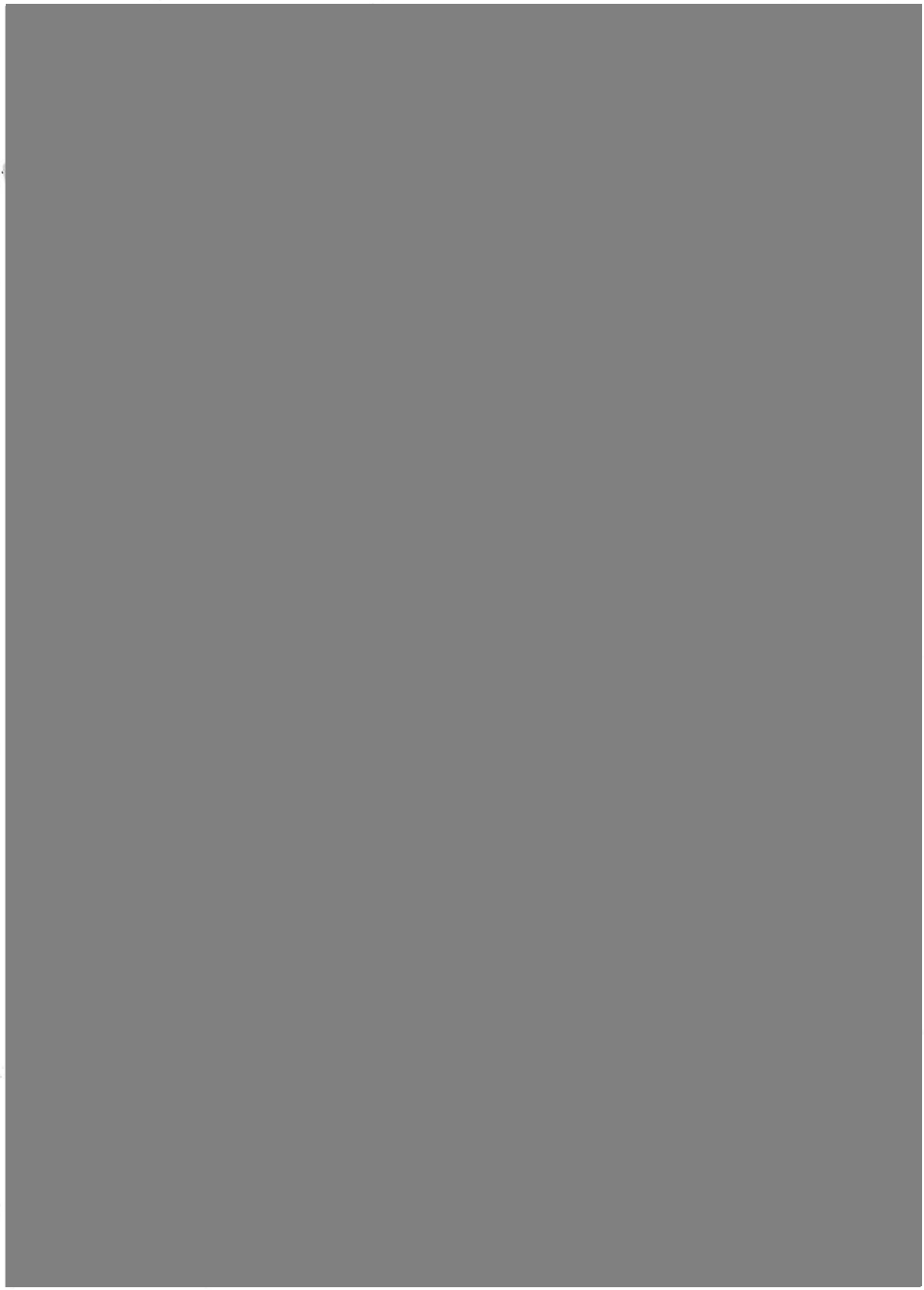
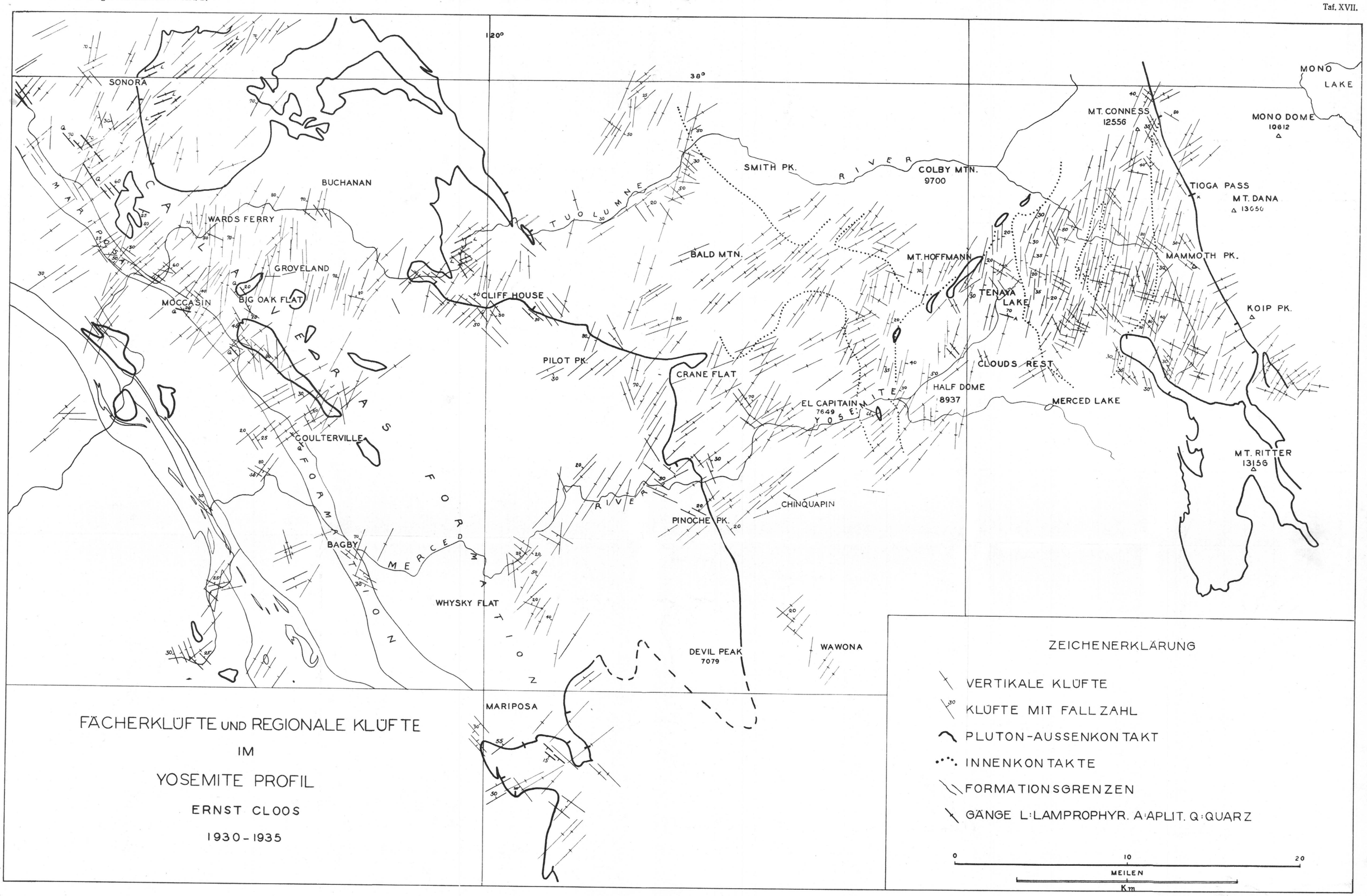




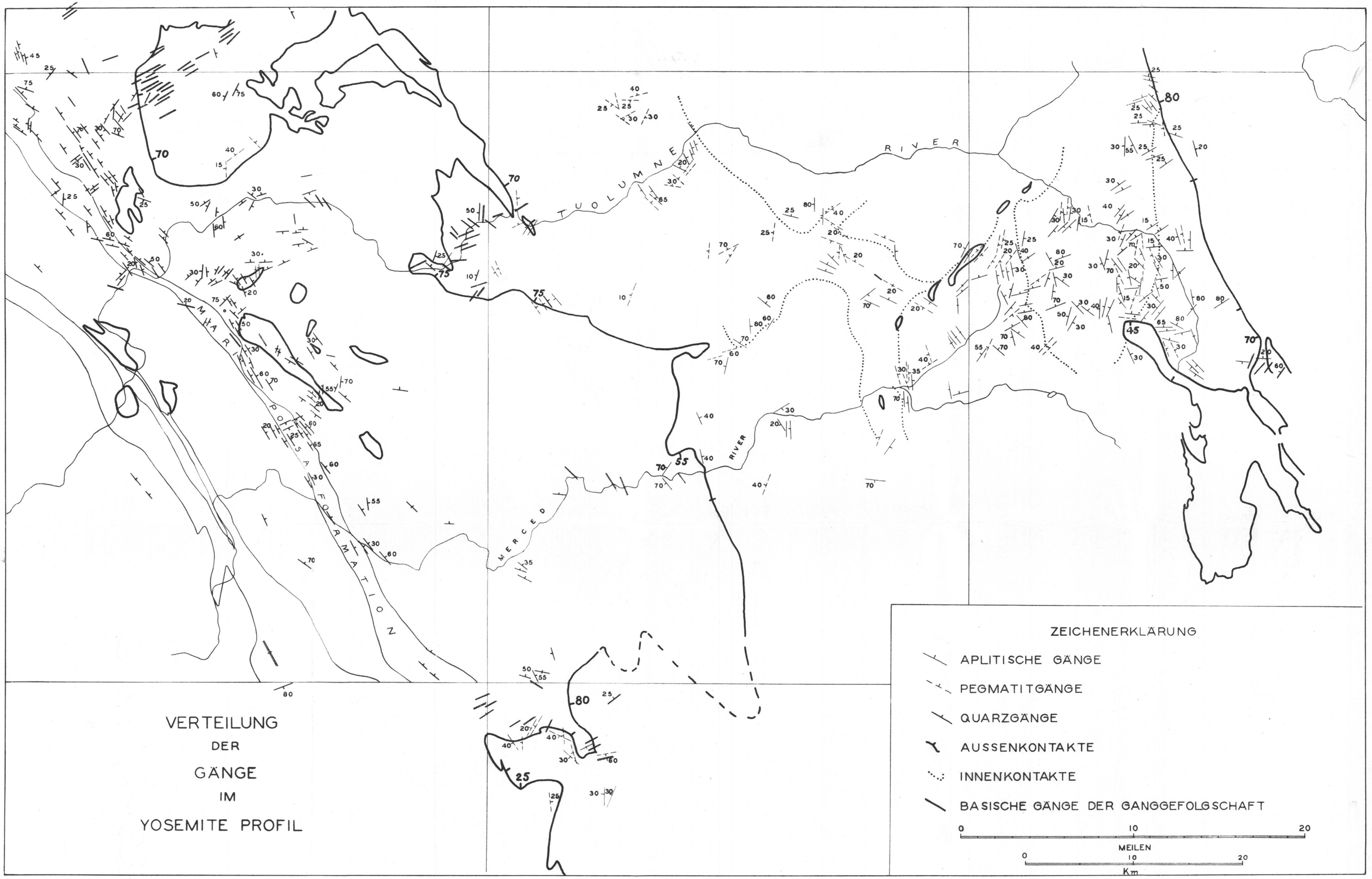
Karte des linearen und flächenhaften primären Parallelgefüges des Sierra Nevada Plutons, Yosemite Profil.



E. Cloos: Der Sierra-Nevada-Pluton in Californien.



Kluftkarte des Yosemite Profils. Fächer- und regionale Klüfte. Der Übersicht halber sind einige Gänge mit eingetragen.



Gangkarte des Yosemite Gebietes, einschließlich der Mother Lode Zone.