The Geographical Cycle
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continental coast, whichever it proves to be, along the Pacific to the meridian of Peter island.

Magnetic observations, deep-sea soundings, and dredgings would be taken throughout the three seasons; but, looking to the uncertain movements of the pack-ice, and to our ignorance of the conditions obtaining over the unknown area, a very wide discretion will be given to the leader of the expedition.

Simultaneously, the German expedition would proceed to its station at Kerguelen island, and thence to the scene of its labours, and, we hope, its discoveries. The ENDERBY or VALDIVIA and WEDDELL quadrants certainly comprise investigations of equal importance, including the discovery of that part of the continental land south of the Weddell sea, which is believed to comprise rocks other than volcanic. Here a landing-party will have work of even greater interest than that which lands in McMurdo bay. But it is not for me even to outline the contemplated German exploration, which has, doubtless, already been systematically planned by the able advisers of the expedition.

I believe that this great geographical enterprise is one of the most important that has ever been conceived. It will add largely to the sum of human knowledge, and, in many ways, will be of direct benefit to mankind. It is a beneficent work, a work which makes for peace and good fellowship among nations. It must rejoice the hearts of all geographers that the countrymen of Humboldt, of Ritter, of Kiepert, of Richthofen, and of Neumayer should combine with the countrymen of Banks, of Rennell, of Murchison, and of Sabine to achieve a grand scientific work which will redound to the honour of both nations.

THE GEOGRAPHICAL CYCLE.

By WILLIAM M. DAVIS, Professor of Physical Geography in Harvar University.

THE GENETIC CLASSIFICATION OF LAND-FORMS.—All the varied forms of the lands are dependent upon—or, as the mathematician would say, are functions of—three variable quantities, which may be called structure, process, and time. In the beginning, when the forces of deformation and uplift determine the structure and attitude of a region, the form of its surface is in sympathy with its internal arrangement, and its height depends on the amount of uplift that it has suffered. If its rocks were unchangeable under the attack of external processes, its surface would remain unaltered until the forces of deformation and uplift acted again;

and in this case structure would be alone in control of form. But no
rocks are unchangeable ; even the most resistant yield under the attack
of the atmosphere, and their waste creeps and washes downhill as
long as any hills remain ; hence all forms, however high and however
resistant, must be laid low, and thus destructive process gains rank
equal to that of structure in determining the shape of a land-mass.
Process cannot, however, complete its work instantly, and the amount
of change from initial form is therefore a function of time.   Time thus
completes the trio of geographical controls, and is, of the three, the one
of most frequent application and of most practical value in geographical
description.

Structure is the foundation of all geographical classifications in
which the trio of controls is recognized.   The Alleghany plateau is a
unit, a " region," because all through its great extent it is composed of
widespread horizontal rock-layers.   The Swiss Jura and the Pennsyl-
vanian Appalachians are units, for they consist of corrugated strata.
The Laurentian highlands of Canada are essentially a unit, for they
consist of greatly disturbed crystalline rocks.   These geographical
units have, however, no such simplicity as mathematical units ; each
one has a certain variety.   The strata of plateaus are not strictly
horizontal, for they slant or roll gently, now this way, now that.   The
corrugations of the Jura or of the Appalachians are not all alike ;
they might, indeed, be more truly described as all different, yet they
preserve their essential features with much constancy.   The disordered
rocks of the Laurentian highlands have so excessively complicated a
structure as at present to defy description, unless item by item ; yet,
in spite of the free variations from a single structural pattern, it is
legitimate and useful to look in a broad way at such a region, and to
regard it as a structural unit.   The forces by which structures and
attitudes have been determined do not come within the scope of geo-
graphical inquiry, but the structures acquired by the action of these
forces serve as the essential basis for the genetic classification of geo-
graphical forms.   For the purpose of this article, it will suffice to
recognize two great structural groups : first, the group of horizontal
structures, including plains, plateaus, and their derivatives, for which
no single name has been suggested ; second, the group of disordered
structures, including mountains and their derivatives, likewise without
a single name.   The second group may be more elaborately subdivided
than the first.

The destructive processes are of great variety—the chemical action
of air and water, and the mechanical action of wind, heat, and cold, of
rain and snow, rivers and glaciers, waves and currents.   But as most
of the land surface of the Earth is acted on chiefly by weather changes
and running water, these will be treated as forming a normal group of
destructive processes ; while the wind of arid deserts and the ice of

frigid deserts will be considered as climatic modifications of the norm, and set apart for particular discussion ; and a special chapter will be needed to explain the action of waves and currents on the shore-lines at the edge of the lands. The various processes by which destructive work is done are in their turn geographical features, and many of them are well recognized as such, as rivers, falls, and glaciers; but they are too commonly considered by geographers apart from the work that they do, this phase of their study being, for some unsatisfactory reason, given over to physical geology. There should be no such separation of agency and work in physical geography, although it is profitable to give separate consideration to the active agent and to the inert mass on which it works.

TIME AS AN ELEMENT IN GEOGRAPHICAL TERMINOLOGY.—The amount of change caused by destructive processes increases with the passage of time, but neither the amount nor the rate of change is a simple function of time. The amount of change is limited, in the first place, by the altitude of a region above the sea; for, however long the time, the normal destructive forces cannot wear a land surface below this ul-timate baselevel of their action ; and glacial and marine forces cannot wear down a land-mass indefinitely beneath sea-level. The rate of change under normal processes, which alone will be considered for the present, is at the very first relatively moderate ; it then advances rather rapidly to a maximum, and next slowly decreases to an indefinitely postponed minimum.

Evidently a longer period must be required for the complete denu-dation of a resistant than of a weak land-mass, but no measure in terms of years or centuries can now be given to the period needed for the effective wearing down of highlands to featureless lowlands. All historic time is hardly more than a negligible fraction of so vast a duration. The best that can be done at present is to give a convenient name to this unmeasured part of eternity, and for this purpose nothing seems more appropriate than a " *geographical cycle.*" When it is possible to establish a ratio between geographical and geological units, there will probably be found an approach to equality between the duration of an average cycle and that of Cretaceous or Tertiary time, as has been indicated by the studies of several geomorphologists.

" THEORETICAL " GEOGRAPHY.—It is evident that a scheme of geo-graphical classification that is founded on structure, process, and time, must be deductive in a high degree. This is intentionally and avowedly the case in the present instance. As a consequence, the scheme gains a very " theoretical " flavour that is not relished by some geographers, whose work implies that geography, unlike all other sciences, should be developed by the use of only certain ones of the mental faculties, chiefly observation, description, and generalization. But nothing seems to me clearer than that geography has already suffered too long from

the disuse of imagination, invention, deduction, and the various other
mental faculties that contribute towards the attainment of a well-tested
explanation.   It is like walking on one foot, or looking with one eye,
to exclude from geography the "theoretical" half of the brain-power,
which other sciences call upon as well as the "practical" half. Indeed,
it is only as a result of misunderstanding that an antipathy is implied
between theory and practice, for in geography, as in all sound scientific
work, the two advance most amiably and effectively together.   Surely
the fullest development of geography will not be reached until all the
mental faculties that are in any way pertinent to its cultivation are
well trained and exercised in geographical investigation.

All this may be stated in another way.   One of the most effective
aids to the appreciation of a subject is a correct explanation of the facts
that it presents.   Understanding thus comes to aid the memory.   But
a genetic classification of geographical forms is, in effect, an explanation
of them; hence such a classification must be helpful to the travelling,
studying, or teaching geographer, provided only that it is a true and
natural classification.   True and natural a genetic classification may
certainly be, for the time is past when even geographers can look on
the forms of lands as "ready made."   Indeed, geographical definitions
and descriptions are untrue and unnatural just so far as they give the
impression that the forms of the lands are of unknown origin, not sus-
ceptible of rational explanation.   From the very beginning of geography
in the lower schools, the pupils should be possessed with the belief that
geographical forms have meaning, and that the meaning or origin of so
many forms is already so well assured that there is every reason to think
that the meaning of all the others will be discovered in due time.   The
explorer of the Earth should be as fully convinced of this principle, and
as well prepared to apply it, as the explorer of the sky is to carry
physical principles to the furthest reach of his telescope, his spectro-
scope, and his camera.   The preparation of route-maps and the deter-
mination of latitude, longitude, and altitude for the more important
points is only the beginning of exploration, which has no end till all the
facts of observation are carried forward to explanation.

It is important, however, to insist that the geographer needs to
know the meaning, the explanation, the origin, of the forms that he
looks at, simply because of the aid thus received when he attempts to
observe and describe the forms carefully.   It is necessary clearly to
recognize this principle, and constantly to bear it in mind, if we would
avoid the error of confounding the objects of geographical and geological
study.   The latter examines the changes of the past for their own sake,
inasmuch as geology is concerned with the history of the Earth ; the
former examines the changes of the past only so far as they serve to
illuminate the present, for geography is concerned essentially with the
Earth as it now exists.   Structure is a pertinent element of geographical

study when, as nearly always, it influences form; no one would to-day attempt to describe the Weald without some reference to the resistent chalk layers that determine its rimming hills.   Process is equally pertinent to our subject, for it has everywhere been influential in determining form to a greater or less degree, and it is everywhere in operation to-day.   It is truly curious to find geographical text-books which accept the movement of winds, currents, and rivers as part of their responsibility, and yet which leave the weathering of the lands and the movement of land-waste entirely out of consideration.   Time is certainly an important geographical element, for where the forces of uplift or deformation have lately (as the Earth views time) initiated a cycle of change, the destructive processes can have accomplished but little work, and the land-form is " young; " where more time has elapsed, the surface will have been more thoroughly carved, and the form thus becomes " mature ; " and where so much time has passed that the originally uplifted surface is worn down to a lowland of small relief, standing but little above sea-level, the form deserves to be called " old."   A whole series of forms must be in this way evolved in the life-history of a single region, and all the forms of such a series, however unlike they may seem at first sight, should be associated under the element of time, as merely expressing the different stages of develop-ment of a single structure.   The larva, the pupa, and the imago of an insect; or the acorn, the full-grown oak, and the fallen old trunk, are no more naturally associated as representing the different phases in the life-history of a single organic species, than are the young mountain block, the maturely carved mountain-peaks and valleys, and the old mountain peneplain, as representing the different stages in the life-history of a single geographic group.   Like land-forms, the agencies that work upon them change their behaviour and their appearance with the passage of time.   A young land-form has young streams of torrential activity, while an old form would have old streams of deliberate or even of feeble current, as will be more fully set forth below.

THE IDEAL GEOGRAPHICAL CYCLE.—The sequence in the develop-mental changes of land-forms is, in its own way, as systematic as the sequence of changes found in the more evident development of organic forms.   Indeed, it is chiefly for this reason that the study of the origin of land-forms—or geomorphogeny, as some call it—becomes a practical aid, helpful to the geographer at every turn.   This will be made clearer by the specific consideration of an ideal case, and here a graphic form of expression will be found of assistance.

The base-line, $a\omega$, of Fig. 1 represents the passage of time, while verticals above the base-line measure altitude above sea-level.   At the epoch 1, let a region of whatever structure and form be uplifted, B representing the average altitude of its higher parts, and A that of its lower parts; thus AB measuring its average initial relief.   The surface

rocks are attacked by the weather. Rain falls on the weathered surface,
and washes some of the loosened waste down the initial slopes to the
trough-lines where two converging slopes meet; there the streams are
formed, flowing in directions consequent upon the descent of the trough-
lines. The machinery of the destructive processes is thus put in motion,
and the destructive development of the region is begun. The larger
rivers, whose channels initially had an altitude, A, quickly deepen their
valleys, and at the epoch 2 have reduced their main channels to a
moderate altitude, represented by C. The higher parts of the inter-
stream uplands, acted on only by the weather without the concentration
of water in streams, waste away much more slowly, and at epoch 2
are reduced in height only to D. The relief of the surface has thus
been increased from AB to CD. The main rivers then deepen their
channels very slowly for the rest of their life, as shown by the curve
CEGJ; and the wasting of the uplands, much dissected by branch
streams, comes to be more rapid than the deepening of the main
valleys, as shown by comparing the curves DFHK and CEGJ. The
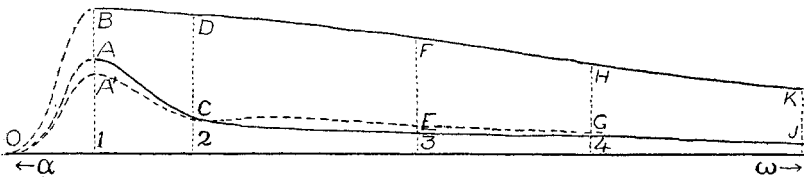period 3–4 is the time of the most rapid consumption of the uplands, and

FIG. 1.

thus stands in strong contrast with the period 1–2, when there was the
most rapid deepening of the main valleys. In the earlier period, the
relief was rapidly increasing in value, as steep-sided valleys were cut
beneath the initial troughs. Through the period 2–3 the maximum
value of relief is reached, and the variety of form is greatly increased
by the headward growth of side valleys. During the period 3–4 re-
lief is decreasing faster than at any other time, and the slope of the
valley sides is becoming much gentler than before; but these changes
advance much more slowly than those of the first period. From epoch 4
onward the remaining relief is gradually reduced to smaller and smaller
measures, and the slopes become fainter and fainter, so that some time
after the latest stage of the diagram the region is only a rolling lowland,
whatever may have been its original height. So slowly do the later
changes advance, that the reduction of the reduced relief JK to half of
its value might well require as much time as all that which has already
elapsed; and from the gentle slopes that would then remain, the further
removal of waste must indeed be exceedingly slow. The frequency of
torrential floods and of landslides in young and in mature mountains,
in contrast to the quiescence of the sluggish streams and the slow

movement of the soil on lowlands of denudation, suffices to show that rate
of denudation is a matter of strictly geographical as well as of geological
interest.

It follows from this brief analysis that a geographical cycle may be
subdivided into parts of unequal duration, each one of which will be
characterized by the strength and variety of relief, and by the rate of
change, as well as by the amount of change that has been accomplished
since the initiation of the cycle.   There will be a brief youth of rapidly
increasing relief, a maturity of strongest relief and greatest variety of
form, a transition period of most rapidly yet slowly decreasing relief,
and an indefinitely long old age of faint relief, on which further changes
are exceedingly slow.   There are, of course, no breaks between these
subdivisions or stages ; each one merges into its successor, yet each one
is in the main distinctly characterized by features found at no other
time.

THE DEVELOPMENT OF CONSEQUENT STREAMS.—The preceding section
gives only the barest outline of the systematic sequence of changes that
run their course through a geographical cycle.   The outline must be at
once gone over, in order to fill in the more important details.   In the
first place, it should not be implied, as was done in Fig. 1, that the
forces of uplift or deformation act so rapidly that no destructive changes
occur during their operation.   A more probable relation at the opening
of a cycle of change places the beginning of uplift at O (Fig. 1),
and its end at 1.   The divergence of the curves OB and OA then
implies that certain parts of the disturbed region were uplifted more
than others, and that, from a surface of no relief at sea-level at epoch O,
an upland having AB relief would be produced at epoch 1.   But even
during uplift, the streams that gather in the troughs as soon as they
are defined do some work, and hence young valleys are already incised
in the trough-bottoms when epoch 1 is reached, as shown by the curve
OA'.   The uplands also waste more or less during the period of dis-
turbance, and hence no absolutely unchanged initial surface should be
found, even for some time anterior to epoch 1.   Instead of looking for
initial divides separating initial slopes that descend to initial troughs
followed by initial streams, such as were implied in Fig. 1 at the epoch
of instantaneous uplift, we must always expect to find some greater or
less advance in the sequence of developmental changes, even in the
youngest known land-forms.   "Initial" is therefore a term adapted to
ideal rather than to actual cases, in treating which the term "sequential"
and its derivatives will be found more appropriate.   All the changes
which directly follow the guidance of the ideal initial forms may be
called consequent; thus a young form would possess consequent divides,
separating consequent slopes which descend to consequent valleys; the
initial troughs being changed to consequent valleys in so far as their
form is modified by the action of the consequent drainage.

THE GRADE OF VALLEY FLOORS.—The larger rivers soon—in terms of the cycle—deepen their main valleys, so that their channels are but little above the baselevel of the region ; but the valley floor cannot be reduced to the absolute baselevel, because the river must slope down to its mouth at the sea-shore. The altitude of any point on a well-matured valley floor must therefore depend on river-slope and distance from mouth. Distance from mouth may here be treated as a constant, although a fuller statement would consider its increase in consequence of delta-growth. River-slope cannot be less, as engineers know very well, than a certain minimum that is determined by volume and by quantity and texture of detritus or load. Volume may be temporarily taken as a constant, although it may easily be shown to suffer important changes during the progress of a normal cycle. Load is small at the beginning, and rapidly increases in quantity and coarseness during youth, when the region is entrenched by steep-sided valleys; it continues to increase in quantity, but probably not in coarseness, during early maturity, when ramifying valleys are growing by headward erosion, and are thus increasing the area of wasting slopes ; but after full maturity, load continually decreases in quantity and in coarseness of texture ; and during old age, the small load that is carried must be of very fine texture or else must go off in solution. Let us now consider how the minimum slope of a main river will be determined.

In order to free the problem from unnecessary complications, let it be supposed that the young consequent rivers have at first slopes that are steep enough to make them all more than competent to carry the load that is washed into them from the wasting surface on either side, and hence competent to entrench themselves beneath the floor of the initial troughs,—this being the condition tacitly postulated in Fig. 1, although it evidently departs from those cases in which deformation produces basins where lakes must form and where deposition (negative denudation) must take place, and also from those cases in which a main-trough stream of moderate slope is, even in its youth, over-supplied with detritus by active side streams that descend steep and long wasting surfaces ; but all these more involved cases may be set aside for the present.

If a young consequent river be followed from end to end, it may be imagined as everywhere deepening its valley, unless at the very mouth. Valley-deepening will go on most rapidly at some point, probably nearer head than mouth. Above this point the river will find its slope increased ; below, decreased. Let the part up-stream from the point of most rapid deepening be called the headwaters; and the part down-stream, the lower course or trunk. In consequence of the changes thus systematically brought about, the lower course of the river will find its slope and velocity decreasing, and its load increasing; that is, its ability to do work is becoming less, while the work that it has to do is becoming

greater. The original excess of ability over work will thus in time be corrected, and when an equality of these two quantities is brought about, the river is *graded*, this being a simple form of expression, suggested by Gilbert, to replace the more cumbersome phrases that are required by the use of " profile of equilibrium " of French engineers. When the graded condition is reached, alteration of slope can take place only as volume and load change their relation ; and changes of this kind are very slow.

In a land-mass of homogeneous texture, the graded condition of a river would be (in such cases as are above considered) first attained at the mouth, and would then advance retrogressively up-stream. When the trunk streams are graded, early maturity is reached; when the smaller headwaters and side streams are also graded, maturity is far advanced; and when even the wet-weather rills are graded, old age is attained. In a land-mass of heterogeneous texture, the rivers will be divided into sections by the belts of weaker and stronger rocks that they traverse; each section of weaker rocks will in due time be graded with reference to the section of harder rock next down-stream, and thus the river will come to consist of alternating quiet reaches and hurried falls or rapids. The less resistant of the harder rocks will be slowly worn down to grade with respect to the more resistant ones that are further down stream; thus the rapids will decrease in number, and only those on the very strongest rocks will long survive. Even these must vanish in time, and the graded condition will then be extended from mouth to head. The slope that is adopted when grade is assumed varies inversely with the volume ; hence rivers retain steep headwaters long after their lower course is worn down almost level; but in old age, even the head-waters must have a gentle declivity and moderate velocity, free from all torrential features. The so-called " normal river," with torrential head-waters and well-graded middle and lower course, is therefore simply a maturely developed river. A young river may normally have falls even in its lower course, and an old river must be free from rapid movement even near its head.

If an initial consequent stream is for any reason incompetent to carry away the load that is washed into it, it cannot degrade its channel, but must aggrade instead (to use an excellent term suggested by Salisbury). Such a river then lays down the coarser part of the offered load, thus forming a broadening flood-land, building up its valley floor, and steepening its slope until it gains sufficient velocity to do the required work. In this case the graded condition is reached by filling up the initial trough instead of by cutting it down. Where basins occur, consequent lakes rise in them to the level of the outlet at the lowest point of the rim. As the outlet is cut down, it forms a sinking local baselevel with respect to which the basin is aggraded ; and as the lake is thus destroyed, it forms a sinking baselevel with respect to which the tributary streams grade their valleys; but, as in

the case of falls and rapids, the local baselevels of outlet and lake are temporary, and lose their control when the main drainage lines are graded with respect to absolute baselevel in early or late maturity.

THE DEVELOPMENT OF RIVER BRANCHES. — Several classes of side streams may be recognized. Some of them are defined by slight initial depressions in the side slopes of the main river-troughs: these form lateral or secondary consequents, branching from a main consequent; they generally run in the direction of the dip of the strata. Others are developed by headward erosion under the guidance of weak sub-structures that have been laid bare on the valley walls of the consequent streams: they follow the strike of the strata, and are entirely regardless of the form of the initial land surface; they may be called subsequent, this term having been used by Jukes in describing the development of such streams. Still others grow here and there, to all appearance by accident, seemingly independent of systematic guidance; they are common in horizontal or massive structures. While waiting to learn just what their control may be, their independence of apparent control may be indicated by calling them "insequent." Additional classes of streams are well known, but cannot be described here for lack of space.

RELATION OF RIVER ABILITY AND LOAD.—As the dissection of a land-mass proceeds with the fuller development of its consequent, subsequent, and insequent streams, the area of steep valley sides greatly increases from youth into early and full maturity. The waste that is delivered by the side branches to the main stream comes chiefly from the valley sides, and hence its quantity increases with the increase of strong dissection, reaching a maximum when the formation of new branch streams ceases, or when the decrease in the slope of the wasting valley sides comes to balance their increase of area. It is interesting to note in this connection the consequences that follow from two contrasted relations of the date for the maximum discharge of waste and of that for the grading of the trunk streams. If the first is not later than the second, the graded rivers will slowly assume gentler slopes as their load lessens; but as the change in the discharge of waste is almost infini-tesimal compared to the amount discharged at any one time, the rivers will essentially preserve their graded condition in spite of the minute excess of ability over work. On the other hand, if the maximum of load is not reached until after the first attainment of the graded con-dition by the trunk rivers, then the valley floors will be aggraded by the deposition of a part of the increasing load, and thus a steeper slope and a greater velocity will be gained whereby the remainder of the increase can be borne along. The bottom of the V-shaped valley, previously carved, is thus slowly filled with a gravelly flood-plain, which continues to rise until the epoch of the maximum load is reached, after which the slow degradation above stated is entered upon. Early maturity may therefore witness a slight shallowing of the main valleys,

instead of the slight deepening (indicated by the dotted line CE in Fig. 1); but late maturity and all old age will be normally occupied by the slow continuation of valley erosion that was so vigorously begun during youth.

THE DEVELOPMENT OF DIVIDES.—There is no more beautiful process to be found in the systematic advance of a geographical cycle than the definition, subdivision, and rearrangement of the divides (water-partings) by which the major and minor drainage basins are separated. The forces of crustal upheaval and deformation act in a much broader way than the processes of land-sculpture; hence at the opening of a cycle one would expect to find a moderate number of large river-basins, somewhat indefinitely separated on the flat crests of broad swells or arches of land surface, or occasionally more sharply limited by the raised edge of faulted blocks. The action of the lateral consequent streams alone would, during youth and early maturity, sharpen all the vague initial divides into well-defined consequent divides, and the further action of insequent and subsequent streams would split up many consequent drainage slopes into subordinate drainage basins, separated by subdivides either insequent or subsequent. Just as the subsequent valleys are eroded by their gnawing streams along weak structural belts, so the subsequent divides or ridges stand up where maintained by strong structural belts. However imperfect the division of drainage areas and the discharge of rainfall may have been in early youth, both are well developed by the time full maturity is reached. Indeed, the more prompt discharge of rainfall that may be expected to result from the development of an elaborate system of subdivides and of slopes from divides to streams should cause an increased percentage of run-off; and it is possible that the increase of river-volume thus brought about from youth to maturity may more or less fully counteract the tendency of increase in river load to cause aggradation. But, on the other hand, as soon as the uplands begin to lose height, the rainfall must decrease; for it is well known that the obstruction to wind-movement caused by highlands is an effective cause of precipitation. While it is a gross exaggeration to maintain that the quaternary Alpine glaciers caused their own destruction by reducing the height of the mountains on which their snows were gathered, it is perfectly logical to deduce a decrease of precipitation as an accompaniment of loss of height from the youth to the old age of a land-mass. Thus many factors must be considered before the life-history of a river can be fully analyzed.

The growth of subsequent streams and drainage areas must be at the expense of the original consequent streams and consequent drainage areas. All changes of this kind are promoted by the occurrence of inclined instead of horizontal rock-layers, and hence are of common occurrence in mountainous regions, but rare in strictly horizontal plains. The changes are also favoured by the occurrence of strong contrasts in the resistance

2 K 2

of adjacent strata.   In consequence of the migration of divides thus
caused, many streams come to follow valleys that are worn down along
belts of weak strata, while the divides come to occupy the ridges that
stand up along the belts of stronger strata; in other words, the simple
consequent drainage of youth is modified by the development of sub-
sequent drainage lines, so as to bring about an *increasing adjustment of
streams to structures*, than which nothing is more characteristic of the
mature stage of the geographical cycle.   Not only so: adjustments of
this kind form one of the strongest, even if one of the latest, proofs of
the erosion of valleys by the streams that occupy them, and of the long
continued action in the past of the slow processes of weathering and
washing that are in operation to-day.

    There is nothing more significant of the advance in geographical
development than the changes thus brought about.   The processes here
involved are too complicated to be now presented in detail, but they may
be briefly illustrated by taking the drainage of a denuded arch, suggested
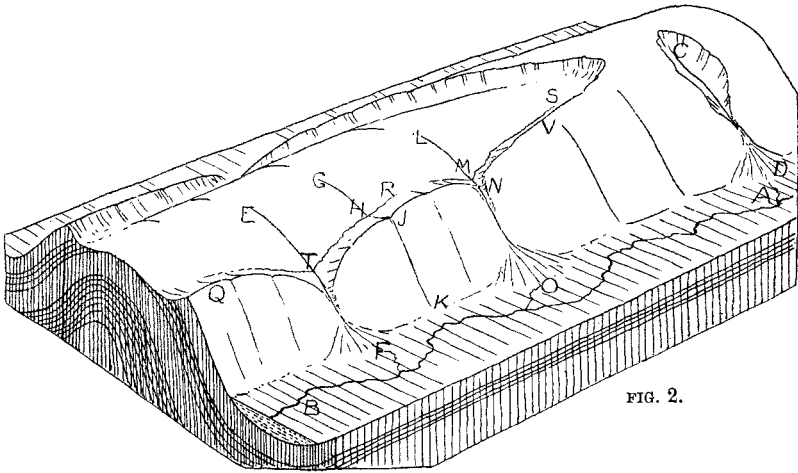
FIG. 2.

by the Jura mountains, as a type example.   AB, Fig. 2, is a main longi-
tudinal consequent stream following a trough whose floor has been
somewhat aggraded by the waste actively supplied by the lateral
consequents, CD, LO, EF, etc.   At an earlier stage of denudation, before
the hard outer layer was worn away from the crown of the mountain arch,
all the lateral consequents headed at the line of the mountain crest.
But, guided by a weak under-stratum, subsequent streams, TR, MS, have
been developed as the branches of certain lateral consequents, EF, LO,
and thus the hard outer layer has been undermined and partly removed,
and many small lateral consequents have been beheaded.   To-day, many
of the laterals, like JK, have their source on the crest of the lateral ridge
VJQ, and the headwaters, such as GH, that once belonged to them, are
now diverted by the subsequent streams to swell the volume of the more

successful laterals, like EF. Similar changes having taken place on the further slope of the mountain arch, we now find the original consequent divide of the arch-crest supplemented by the subsequent divides formed by the lateral ridges. A number of short streams, like JH, belonging to a class not mentioned above, run down the inner face of the lateral ridges to a subsequent stream, RT. These short streams have a direction opposite to that of the original consequents, and may therefore be called obsequents. As denudation progresses, the edge of the lateral ridge will be worn further from the arch-crest; in other words, the subsequent divide will migrate towards the main valley, and thus a greater length will be gained by the diverted consequent headwaters, GH, and a greater volume by the subsequents, SM and RT. During these changes the inequality that must naturally prevail between adjacent successful consequents, EF and LO, will eventually allow the subsequent branch, RT, of the larger consequent, EF, to capture the headwaters, LM and SM, of the smaller consequent, LO. In late maturity the headwaters of so many lateral consequents may be diverted to swell the volume of EF, that the main longitudinal consequent above the point F may be reduced to relatively small volume.

THE DEVELOPMENT OF RIVER MEANDERS.—It has been thus far implied that rivers cut their channels vertically downward, but this is far from being the whole truth. Every turn in the course of a young consequent stream causes the stronger currents to press toward the outer bank, and each irregular, or, perhaps, subangular bend is thus rounded out to a comparatively smooth curve. The river therefore tends to depart from its irregular initial path (background block of Fig. 3) towards a serpentine course, in which it swings to right and left over a broader belt than at first. As the river cuts downwards and outwards at the same time, the valley-slopes become unsymmetrical (middle block of Fig. 3), being steeper on the side toward which the current is urged by centrifugal force. The steeper valley side thus gains the form of a half-amphitheatre, into which the gentler sloping side enters as a spur of the opposite uplands. When the graded condition is attained by the stream, downward cutting practically ceases, but outward cutting continues; a normal flood-plain is then formed as the channel is withdrawn from the gently sloping side of the valley (foreground block of Fig. 3). Flood-plains of this kind are easily distinguished in their early stages from those already mentioned (formed by aggrading the flat courses of incompetent young rivers, or by aggrading the graded valleys of over-loaded rivers in early maturity); for these occur in detached lunate areas, first on one side, then on the other side of the stream, and always systematically placed at the foot of the gentler sloping spurs. But, as time passes, the river impinges on the up-stream side, and withdraws from the down-stream side of every spur, and thus the spurs are gradually consumed; they are first sharpened, so as better to observe

their name; they are next reduced to short cusps; then they are worn back to blunt salients; and finally, they are entirely consumed, and the river wanders freely on its open flood-plain, occasionally swinging against the valley side, now here, now there. By this time the curves of youth are changed into systematic meanders, of radius appropriate to river volume; and, for all the rest of an undisturbed life, the river persists in the habit of serpentine flow. The less the slope of the flood-plain becomes in advancing old age, the larger the arc of each meander,
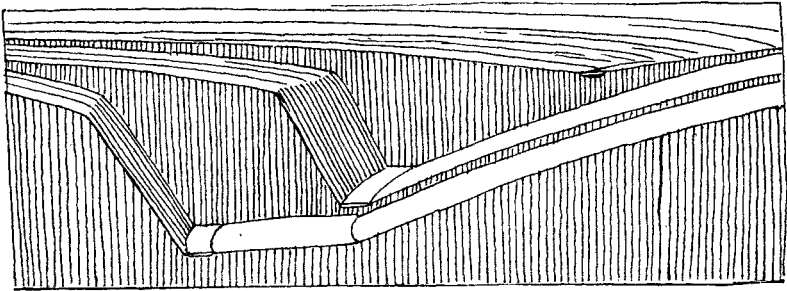
FIG. 3.

and hence the longer the course of the river from any point to its mouth. Increase of length from this cause must tend to diminish fall, and thus to render the river less competent than it was before; and the result of this tendency will be to retard the already slow process by which a gently sloping flood-plain is degraded so as to approach coincidence with a level surface; but it is not likely that old rivers often remain undisturbed long enough for the full realization of these theoretical conditions.

The migration of divides must now and then result in a sudden increase in the volume of one river and in a correspondingly sudden decrease of another. After such changes, accommodation to the changed volume must be made in the meanders of each river affected. The one that is increased will call for enlarged dimensions; it will usually adopt a gentler slope, thus terracing its flood-plain, and demand a greater freedom of swinging, thus widening its valley. The one that is decreased will have to be satisfied with smaller dimensions; it will wander aimlessly in relatively minute meanders on its flood-plain, and from increase of length, as well as from loss of volume, it will become incompetent to transport the load brought in by the side streams, and thus its flood-plain must be aggraded. There are beautiful examples known of both these peculiar conditions.

THE DEVELOPMENT OF GRADED VALLEY SIDES.—When the migration of divides ceases in late maturity, and the valley floors of the adjusted

streams are well graded, even far toward the headwaters, there is still to be completed another and perhaps even more remarkable sequence of systematic changes than any yet described : this is the development of graded waste slopes on the valley sides. It is briefly stated that valleys are eroded by their rivers; yet there is a vast amount of work performed in the erosion of valleys in which rivers have no part. It is true that rivers deepen the valleys in the youth, and widen the valley floors during the maturity and old age of a cycle, and that they carry to the sea the waste denuded from the land ; it is this work of transportation to the sea that is peculiarly the function of rivers; but the material to be transported is supplied chiefly by the action of the weather on the steeper consequent slopes and on the valley sides.   The transportation of the weathered material from its source to the stream in the valley bottom is the work of various slow-acting processes, such as the surface wash of rain, the action of ground water, changes of temperature, freezing and thawing, chemical disintegration and hydration, the growth of plant-roots, the activities of burrowing animals. All these cause the weathered rock waste to wash and creep slowly downhill, and in the motion thus ensuing there is much that is analogous to the flow of a river.   Indeed, when considered in a very broad and general way, a river is seen to be a moving mixture of water and waste in variable proportions, but mostly water ; while a creeping sheet of hillside waste is a moving mixture of waste and water in variable proportions, but mostly waste.   Although the river and the hillside waste-sheet do not resemble each other at first sight, they are only the extreme members of a continuous series; and when this generalization is appreciated, one may fairly extend the " river " all over its basin, and up to its very divides.   Ordinarily treated, the river is like the veins of a leaf; broadly viewed, it is like the entire leaf. The verity of this comparison may be more fully accepted when the analogy, indeed, the homology, of waste-sheets and water-streams is set forth.

In the first place, a waste-sheet moves fastest at the surface and slowest at the bottom, like a water-stream.   A graded waste-sheet may be defined in the very terms applicable to a graded water-stream ; it is one in which the ability of the transporting forces to do work is equal to the work that they have to do.   This is the condition that obtains on those evenly slanting, waste-covered mountain-sides which have been reduced to a slope that engineers call " the angle of repose," because of the apparently stationary condition of the creeping waste, but that should be called, from the physiographic standpoint, " the angle of first-developed grade."   The rocky cliffs and ledges that often surmount graded slopes are not yet graded ; waste is removed from them faster than it is supplied by local weathering and by creeping from still higher slopes, and hence the cliffs and ledges are left almost bare ;

they correspond to falls and rapids in water-streams, where the current
is so rapid that its cross-section is much reduced. A hollow on an
initial slope will be filled to the angle of grade by waste from above;
the waste will accumulate until it reaches the lowest point on the rim
of the hollow, and then outflow of waste will balance inflow; and
here is the evident homologue of a lake.

In the second place, it will be understood, from what has already
been said, that rivers normally grade their valleys retrogressively from
the mouth headwards, and that small side streams may not be graded
till long after the trunk river is graded. So with waste-sheets; they
normally begin to establish a graded condition at their base, and then
extend it up the slope of the valley side whose waste they "drain."
When rock-masses of various resistance are exposed on the valley side,
each one of the weaker is graded with reference to the stronger one
next downhill; and the less resistant of the stronger ones are graded
with reference to the more resistant (or with reference to the base of
the hill): this is perfectly comparable to the development of graded
stretches and to the extinction of falls and rapids in rivers. Ledges
remain ungraded on ridge-crests and on the convex front of hill spurs
long after the graded condition is reached in the channels of wet-weather
streams in the ravines between the spurs; this corresponds nicely with
the slower attainment of grade in small side streams than in large trunk
rivers. But as late maturity passes into old age, even the ledges on
ridge-crests and spur-fronts disappear, all being concealed in a universal
sheet of slowly creeping waste. From any point on such a surface a
graded slope leads the waste down to the streams. At any point the
agencies of removal are just able to cope with the waste that is there
weathered *plus* that which comes from further uphill. This wonderful
condition is reached in certain well-denuded mountains, now subdued
from their mature vigour to the rounded profiles of incipient old age.
When the full meaning of their graded form is apprehended, it con-
stitutes one of the strongest possible arguments for the sculpture of the
lands by the slow processes of weathering, long continued. To look
upon a landscape of this kind without any recognition of the labour
expended in producing it, or of the extraordinary adjustments of streams
to structures, and of waste to weather, is like visiting Rome in the
ignorant belief that the Romans of to-day have had no ancestors.

Just as graded rivers slowly degrade their courses after the period
of maximum load is past, so graded waste-sheets adopt gentler and
gentler slopes when the upper ledges are consumed and coarse waste is
no longer plentifully shed to the valley sides below. A changing
adjustment of a most delicate kind is here discovered. When the graded
slopes are first developed, they are steep, and the waste that covers them
is coarse and of moderate thickness; here the strong agencies of removal
have all they can do to dispose of the plentiful supply of coarse waste

from the strong ledges above, and the no less plentiful supply of waste that is weathered from the weaker rocks beneath the thin cover of detritus. In a more advanced stage of the cycle, the graded slopes are moderate, and the waste that covers them is of finer texture and greater depth than before; here the weakened agencies of removal are favoured by the slower weathering of the rocks beneath the thickened waste cover, and by the greater refinement (reduction to finer texture) of the loose waste during its slow journey. In old age, when all the slopes are very gentle, the agencies of waste-removal must everywhere be weak, and their equality with the processes of waste-supply can be maintained only by the reduction of the latter to very low values. The waste-sheet then assumes a great thickness—even 50 or 100 feet—so that the progress of weathering is almost *nil*; at the same time, the surface waste is reduced to extremely fine texture, so that some of its particles may be moved even on faint slopes. Hence the occurrence of deep soils is an essential feature of old age, just as the occurrence of bare ledges is of youth. The relationships here obtaining are as significant as those which led Playfair to his famous statement concerning the origin of valleys by the rivers that drain them.

OLD AGE.—Maturity is past and old age is fully entered upon when the hilltops and the hillsides, as well as the valley floors, are graded. No new features are now developed, and those that have been earlier developed are weakened or even lost. The search for weak structures and the establishment of valleys along them has already been thoroughly carried out; now the larger streams meander freely in open valleys and begin to wander away from the adjustments of maturity. The active streams of the time of greatest relief now lose their headmost branches, for the rainfall is lessened by the destruction of the highlands, and the run-off of the rain water is retarded by the flat slopes and deep soils. The landscape is slowly tamed from its earlier strength, and presents only a succession of gently rolling swells alternating with shallow valleys, a surface everywhere open to occupation. As time passes, the relief becomes less and less; whatever the uplifts of youth, whatever the disorder and hardness of the rocks, an almost featureless plain (a pene-plain) showing little sympathy with structure, and controlled only by a close approach to baselevel, must characterize the penultimate stage of the uninterrupted cycle; and the ultimate stage would be a plain without relief.

Some observers have doubted whether even the penultimate stage of a cycle is ever reached, so frequently do movements in the Earth's crust cause changes in its position with respect to baselevel. But, on the other hand, there are certain regions of greatly disordered structure, whose small relief and deep soils cannot be explained without supposing them to have, in effect, passed through all the stages above described—and doubtless many more, if the whole truth were told—before reaching the

penultimate, whose features they verify. In spite of the great distur-
bances that such regions have suffered in past geological periods, they
have afterwards stood still so long, so patiently, as to be worn down to
pene-plains over large areas, only here and there showing residual reliefs
where the most resistant rocks still stand up above the general level.
Thus verification is found for the penultimate as well as for many earlier
stages of the ideal cycle. Indeed, although the scheme of the cycle is
here presented only in theoretical form, the progress of developmental
changes through the cycle has been tested over and over again for many
structures and for various stages; and on recognizing the numerous
accordances that are discovered when the consequences of theory are
confronted with the facts of observation, one must feel a growing belief
in the verity and value of the theory that leads to results so satisfactory.

It is necessary to repeat what has already been said as to the
practical application of the principles of the geographical cycle. Its
value to the geographer is not simply in giving explanation to land-
forms; its greater value is in enabling him to see what he looks at, and
to say what he sees. His standards of comparison, by which the un-
known are likened to the known, are greatly increased over the short
list included in the terminology of his school-days. Significant features
are consciously sought for; exploration becomes more systematic and
less haphazard. "A hilly region" of the unprepared traveller becomes
(if such it really be) "a maturely dissected upland" in the language of
the better prepared traveller; and the reader of travels at home gains
greatly by the change. "A hilly region" brings no definite picture
before the mental eyes. "A maturely dissected upland" suggests a
systematic association of well-defined features; all the streams at grade,
except the small headwaters; the larger rivers already meandering on
flood-plained valley floors; the upper branches ramifying among spurs
and hills, whose flanks show a good beginning of graded slopes; the
most resistant rocks still cropping out in ungraded ledges, whose
arrangement suggests the structure of the region. The practical value
of this kind of theoretical study seems to me so great that, among
various lines of work that may be encouraged by the Councils of the
great Geographical Societies, I believe there is none that would bring
larger reward than the encouragement of some such method as is here
outlined for the systematic investigation of land-forms.

Some geographers urge that it is dangerous to use the theoretical
or explanatory terminology involved in the practical application of the
principles of the geographical cycle; mistakes may be made, and harm
would thus be done. There are various sufficient answers to this objec-
tion. A very practical answer is that suggested by Penck, to the effect
that a threefold terminology should be devised—one set of terms being
purely empirical, as "high," "low," "cliff," "gorge," "lake," "island;"
another set being based on structural relations, as "monoclinal ridge,"

" transverse valley," " lava-capped mesa ;" and the third being reserved
for explanatory relations, as " mature dissection," " adjusted drainage,"
" graded slopes."   Another answer is that the explanatory terminology
is not really a novelty, but only an attempt to give a complete and sys-
tematic expansion to a rather timid beginning already made ; a sand-dune
is not simply a hillock of sand, but a hillock heaped by the wind ; a delta
is not simply a plain at a river mouth, but a plain formed by river action; a
volcano is not simply a mountain of somewhat conical form, but a mountain
formed by eruption.   It is chiefly a matter of experience and tempera-
ment where a geographer ceases to apply terms of this kind.   But little
more than half a century ago, the erosion of valleys by rivers was either
doubted or not thought of by the practical geographer; to-day, the
mature adjustment of rivers to structures is in the same position; and
here is the third, and to my mind the most important, answer to those
conservatives who would maintain an empirical position for geography,
instead of pressing forward toward the rational and explanatory geo-
graphy of the future.   It cannot be doubted, in view of what has already
been learned to-day, that an essentially explanatory treatment must in
the next century be generally adopted in all branches of geographical
study; it is full time that an energetic beginning should be made
towards so desirable an end.

INTERRUPTIONS OF THE IDEAL CYCLE.—One of the first objections that
might be raised against a terminology based on the sequence of changes
through the ideal uninterrupted cycle, is that such a terminology can
have little practical application on an Earth whose crust has the habit
of rising and sinking frequently during the passage of geological time.
To this it may be answered, that if the scheme of the geographical
cycle were so rigid as to be incapable of accommodating itself to the
actual condition of the Earth's crust, it would certainly have to be
abandoned as a theoretical abstraction; but such is by no means the
case.   Having traced the normal sequence of events through an ideal
cycle, our next duty is to consider the effects of any and all kinds of
movements of the land-mass with respect to its baselevel.   Such move-
ments must be imagined as small or great, simple or complex, rare or
frequent, gradual or rapid, early or late.   Whatever their character,
they will be called "interruptions," because they determine a more or
less complete break in processes previously in operation, by beginning
a new series of processes with respect to the new baselevel.   Whenever
interruptions occur, the pre-existent conditions that they interrupt can
be understood only after having analyzed them in accordance with the
principles of the cycle, and herein lies one of the most practical appli-
cations of what at first seems remotely theoretical.   A land-mass,
uplifted to a greater altitude than it had before, is at once more intensely
attacked by the denuding processes in the new cycle thus initiated; but
the forms on which the new attack is made can only be understood by

considering what had been accomplished in the preceding cycle previous to its interruption.   It will be possible here to consider only one or two specific examples from among the multitude of interruptions that may be imagined.

Let it be supposed that a maturely dissected land-mass is evenly uplifted 500 feet above its former position.   All the graded streams are hereby revived to new activities, and proceed to entrench their valley floors in order to develop graded courses with respect to the new baselevel.   The larger streams first show the effect of the change ; the smaller streams follow suit as rapidly as possible.   Falls reappear for a time in the river-channels, and then are again worn away.   Adjustments of streams to structures are carried further in the second effort of the new cycle than was possible in the single effort of the previous cycle. Graded hillsides are undercut; the waste washes and creeps down from them, leaving a long even slope of bare rock; the rocky slope is hacked into an uneven face by the weather, until at last a new graded slope is developed.   Cliffs that had been extinguished on graded hillsides in the previous cycle are thus for a time brought to life again, like the falls in the rivers, only to disappear in the late maturity of the new cycle.

The combination of topographic features belonging to two cycles may be called "composite topography," and many examples could be cited in illustration of this interesting association.   In every case, description is made concise and effective by employing a terminology derived from the scheme of the cycle.   For example, Normandy is an uplifted peneplain, hardly yet in the mature stage of its new cycle; thus stated, explanation is concisely given to the meandering course of the rather narrow valley of the Seine, for this river has carried forward into the early stages of the new cycle the habit of swinging in strong meanders that it had learned in the later stages of the former cycle.

If the uplift of a dissected region be accompanied by a gentle tilting, then all the water-streams and waste-streams whose slope is increased will be revived to new activity ; while all those whose slope is decreased will become less active.   The divides will migrate into the basins of the less active streams, and the revived streams will gain length and drain-age area.   If the uplift be in the form of an arch, some of the weaker streams whose course is across the axis of the arch may be, as it were, " broken in half ; " a reversed direction of flow may be thus given to one part of the broken stream; but the stronger rivers may still persevere across the rising arch in spite of its uplift, cutting down their channels fast enough to maintain their direction of flow unchanged ; and such rivers are known as " antecedent."

The changes introduced by an interruption involving depression are easily deduced.   Among their most interesting features is the invasion of the lower valley floors by the sea, thus " drowning " the valleys to a

certain depth, and converting them into bays. Movements that tend to produce trough-like depressions across the course of a river usually give birth to a lake of water or waste in the depressed part of the river valley. In mountain ranges frequent and various interruptions occur during the long period of deformation; the Alps show so many recent interruptions that a student there would find little use for the ideal cycle; but in mountain regions of ancient deformation, the disturbing forces seem to have become almost extinct, and there the ideal cycle is almost realized. Central France gives good illustration of this principle. It is manifest that one might imagine an endless number of possible combinations among the several factors of structure, stage of development at time of interruption, character of interruption, and time since interruption; but space cannot be here given to their further consideration.

ACCIDENTAL DEPARTURES FROM THE IDEAL CYCLE.—Besides the interruptions that involve movements of a land-mass with respect to baselevel, there are two other classes of departure from the normal or ideal cycle that do not necessarily involve any such movements: these are changes of climate and volcanic eruptions, both of which occur so arbitrarily as to place and time that they may be called "accidents." Changes of climate may vary from the normal towards the frigid or the arid, each change causing significant departures from normal geographical development. If a reverse change of climate brings back more normal conditions, the effects of the abnormal "accident" may last for some small part of a cycle's duration before they are obliterated. It is here that features of glacial origin belong, so common in north-western Europe and north-eastern America. Judging by the present analysis of glacial and interglacial epochs during quaternary time, or of humid and arid epochs in the Great Salt Lake region, it must be concluded that accidental changes may occur over and over again within a single cycle.

In brief illustration of the combined interruptions and accidents, it may be said that southern New England is an old mountain region, which had been reduced to a pretty good peneplain when further denudation was interrupted by a slanting uplift, with gentle descent to the south-east; that in the cycle thus introduced the tilted peneplain was denuded to a sub-mature or late mature stage (according to the strength or weakness of its rocks); and that the maturely dissected region was then glaciated and slightly depressed so recently that little change has happened since. An instructive picture of the region may be conceived from this brief description.

Many volcanic eruptions produce forms so large that they deserve to be treated as new structural regions; but when viewed in a more general way, a great number of eruptions, if not the greater number, produce forms of small dimensions compared to those of the structures on which

they are superposed : the volcanoes of central France are good instances
of this relation.   Thus considered, volcanoes and lava-flows are so
arbitrarily placed in time and space that their classification under the
head of " accidents " is warranted.   Still further ground for this classi-
fication is found when the effects of a volcanic eruption on the pre-
existent processes of land-sculpture are examined.   A valley may be
blockaded by a growing cone and its lava-flows ; lakes may form in the
up-stream portion of such a valley, even if it be mature or old.   If the
blockade be low, the lake will overflow to one side of the barrier, and
thus the river will be locally displaced from its former course, however
well adjusted to a weak structure that course may have been.   If the
blockade be higher than some points on the headwater divides, the lake
will overflow " backwards," and the upper part of the river system will
become tributary to an adjacent system.   The river must cut a gorge
across the divide, however hard the rocks are there ; thus systematic
adjustments to structure are seriously interfered with, and accidental
relations are introduced.   The form of the volcanic cone and the sprawl-
ing flow of its lava-streams are quite out of accord with the forms that
characterize the surrounding region.   The cone arbitrarily forms a
mountain, even though the subjacent rocks may be weak ; the lava-flows
aggrade valleys that should be degraded.   During the dissection of the
cone, a process that is systematic enough if considered for itself alone,
a radial arrangement of spurs and ravines will be developed ; in long
future time the streams of such ravines may cut down through the
volcanic structures, and thus superpose themselves most curiously on
the underlying structures.   The lava-flows, being usually more resistant
than the rocks of the district that they invade, gain a local relief as the
adjoining surface is lowered by denudation ; thus an inversion of topo-
graphy is brought about, and a " table-mountain " comes to stand where
formerly there had been the valley that guided the original course of
the lava-flow.   The table-mountain may be quite isolated from its
volcanic source, where the cone is by this time reduced to a knob or
" butte."   But although these various considerations seem to me to
warrant the classification of volcanic forms as " accidental," in contrast
to the systematic forms with which they are usually associated, great
importance should not be attached to this method of arrangement ; it
should be given up as soon as a more truthful or more convenient classi-
fication is introduced.

THE FORMS ASSUMED BY LAND WASTE.—An extension of the subject
treated in the section on Graded Valley Sides, would lead to a general
discussion of the forms assumed by the waste of the land on the way to
the sea ; one of the most interesting and profitable topics for investiga-
tion that has come under my notice.   Geographers are well accustomed
to giving due consideration to the forms assumed by the water-drainage
of the land on the way to the sea, and a good terminology is already in

use for naming them ; but much less consideration is given to the forms
assumed by the waste that slowly moves from the land to the sea.
They are seldom presented in their true relations; many of them have
no generally accepted names—for example, the long slopes of waste that
reach forward from the mountains into the desert basins of Persia;
forms as common as alluvial fans are unmentioned in all but the most
recent school-books; and such features as till plains, moraines, and
drumlins are usually given over to the geologist, as if the geographer
had nothing to do with them! There can be no question of the great
importance of waste-forms to the geographer, but it is not possible here
to enter into their consideration. Suffice it to say that waste-forms con-
stitute a geographical group which, like water-forms, stand quite apart
from such groups as mountains and plateaus. The latter are forms of
structure, and should be classified according to the arrangement of their
rocks, and to their age or stage of development. The former are forms
of process, and should be classified according to the processes involved,
and to the stage that they have reached. The application of this
general principle gives much assistance in the description of actual
landscapes.

Lack of space prevents due consideration here of the development of
shore-lines, a subject not less interesting, suggestive, and helpful than
the development of inland forms; but I shall hope to return on some
later occasion to a discussion of shore features, when it may be found
that much of the terminology already introduced is again applicable. In
closing this article, I must revert, if even for a third time, to the
practical side of the theoretical cycle, with its interruptions and acci-
dents. It cannot be too carefully borne in mind that the explanation of
the origin of land-forms is not for its own sake added to the study of
geography, but for the sake of the aid that explanation gives to the
observation and description of existing geographical features. The
sequence of forms developed through the cycle is not an abstraction that
one leaves at home when he goes abroad; it is literally a *vade-mecum* of
the most serviceable kind. During the current year that I am spending
in Europe, the scheme and the terminology of the cycle have been of the
greatest assistance in my studies. Application of both scheme and
terminology is found equally well in the minute and infantile coastal
plains that border certain stretches of the Scotch shore-line in consequence
of the slight post-glacial elevation of the land, and in the broad and aged
central plateau of France, where the young valleys of to-day result from
the uplift of the region, and the revival of its rivers after they had sub-
maturely dissected a pre-existent peneplain. The adjustments of streams
to structures brought about by the interaction of the waxing Severn and
the waning Thames, prove to be even more striking than when I first
noticed them in 1894.* The large ancient delta of the Var, between

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* See *Geographical Journal*, 1895 ; and *Proceedings Geologists' Association*, 1899.

Nice and Cannes, now uplifted more than 200 metres, and maturely dissected, must come to be the type example of this class of forms. The Italian Riviera, west of Genoa, may be concisely described as a region of subdued mountains that has been partly submerged and that is now approaching maturity of shore-line features in the cycle thus initiated : one may picture, from this brief statement, the mountain spurs with well-graded slopes, limited by a very irregular shore-line when first depressed, but now fronting in a comparatively simple shore-line of cliffed head-lands and filled bays. The peninsula of Sorrento, on its northern side, once resembled the Riviera, but it has now been elevated 50 metres, and its uplifted bay-plains have cliffed fronts. The lower Tiber, whose mature valley floor is now somewhat wider than its meander belt, is consequent upon a volcanic accident, for it follows the trough between the slopes of the Bracciano volcanic centre on the north-west, and the Alban centre on the south-east; further up-stream, as far as Orvieto, the river, as a rule, follows a trough between the Apennines and the three volcanic centres of Bolsena, Vico, and Bracciano. The Lepini mountains, a maturely carved block of moderately deformed Cretaceous limestones south of the Alban volcanic group, has along a part of its north-eastern base a very young fault cliff, by which the graded slopes of the spurs and ravines are abruptly cut off; the fault cliff is easily recognized from the train on the line between Rome and Naples.

Botanists and zoologists know very well that a trained observer can easily recognize and describe many small items of form that pass without notice from the untrained observer. It is the same in geography, and the only question is—How can the desired training be secured ? Of the many methods of geographical training, I believe that, as far as the forms of the land are concerned, no method can equal the value of one in which explanation is made an essential feature along with observation, for there is no other in which so many mental faculties are exercised.

CONTRIBUTIONS TO THE GEOGRAPHY OF LAKE URMI AND ITS NEIGHBOURHOOD.*

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THE following notes are the result of travels in the plateau of Azerbaijan during the summer months of 1898, for the purpose of investigating the fauna and flora of the salt lake of Urmi and of its fresh-water tributaries.

The map of the lake is an attempt to lessen some of the errors of other maps. It is a compromise between my own observations and the best maps to which I have had access. I should like to draw especial attention to the inaccuracies and unsatisfactory discrepancies of all published maps of the district, and to the importance of a more

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* Map, p. 592.