where large properties are the rule and peasant proprietorship is thus excluded. Further, the land is not always divided up at the death of the head of the household as elsewhere in France; it is quite usual to find that it descends, either altogether or in greater part, to the eldest son, who is obliged to find money to pay off his brothers and sisters. It is with this object that he goes forth to seek for work and money. So soon as a small piece of land is put up for sale, many applicants present themselves, and barren as it is, the land fetches high prices. Professor Demangeon notes, as a curious little point, that when the working men in the large towns strike for higher wages it is often because of the call of the land in their native Mountain.

This greed of land is bringing about a number of minor changes in the distribution of property. Especially noticeable is the tendency to disappearance shown by common lands, more and more divided up among peasant proprietors, and the gradual reduction in the number of absentee landowners. The division of the communal lands was and is bitterly opposed by the large proprietors, who object to its division into equal parts, instead of upon the basis of the size of the flocks. But the division goes on none the less, for by it the small holders obtain new lands for growing rye and also regions capable of afforestation. The gradual growth of small holdings is aided by the diminution in the amount of labour necessary to work the larger. Thus holdings of from twelve to seventy-five acres increase in number, and each is cultivated by and for its proprietor.

Where land is rented the ordinary farm lease tends more and more to replace the system of métayage (payment in kind). Under the latter system the flocks belong to the proprietor, who decides all questions of buying, selling, and cropping. The system has the great advantage of permitting a peasant to cultivate without possessing much capital, but it is proving intolerable to the peasant of to-day, who prefers to pay a money rent and have freedom to follow his own ideas. Thus while métayage lingers on the large estates, the rent system appeals much more to the present-day farmer, who regards it as a stage in the acquisition of land.

It will be noted that recent developments in this barren upland region of France are very different from those which are taking place in the Highlands of Scotland, where the geographical conditions present certain similarities.

CONSTRUCTIVE WATERFALLS.

By Professor J. W. Gregory, F.R.S., D.Sc., University, Glasgow.

(With Maps and Diagrams.)

The excavation of valleys by waterfalls is one of the best known and most effective processes by which rivers cut down the surface of the earth. The influence of waterfalls is usually regarded as solely destructive, and as always helping to lower the land. They undermine and

cut backward the rock faces over which they fall: by this recession they excavate deep gorges; and the existence of these gorges enables the adjacent country to be lowered to the level of the valley floors. The waterfalls, moreover, empty any lakes they may reach in their retreat, while the ravines below the falls may drain the springs and thus desiccate the neighbouring highlands. Observations in various countries had suggested to me that waterfalls may sometimes be constructive instead of destructive, and that they may reverse their usual procedure, advancing instead of retreating, filling valleys instead of excavating them, and forming alluvial plains and lakes instead of destroying them. The best illustrations I have seen of such advancing, constructive waterfalls are on some rivers of Dalmatia and Bosnia, where they occur in various stages of development.

1. The Kerka Falls.

The famous falls on the Kerka river near Scardona, about ten miles north-east of the port of Sebenico, are a large example of the simplest variety of constructive waterfalls. The falls are over a bar of calcareous tufa, which they have built up across the Kerka valley. They are the chief falls on the Kerka river, and are well known, as they are easily accessible and are generally described as one of the most picturesque sights in Dalmatia. Their beauty is due to their terraced structure, the variety of the tufa platforms over which the water falls, and the luxuriant vegetation on the islands between the numerous branches of the river.

The falls are situated about three miles from Scardona, where the river is at sea-level. Above Scardona the Kerka valley is a deep trough cut to a depth of from 450 to 600 feet through a limestone plateau. The floor of the valley is flat and about 300 yards wide, and the walls are steep, smooth, and spurless.

The right or north-eastern bank consists of Eocene foraminiferal limestones, and the south-western side is of unfossiliferous Cretaceous limestones. The beds have a steep dip to the south-west and have been folded into an isoclinal.[1] From Scardona the valley goes first for a mile to the east-north-east across the strike of the rocks; it then makes a right-angled bend and continues as a strike valley for nearly two miles to the south-south-east. The rock-barrier at the falls is therefore at right angles to the grain of the rocks, and the existence of a bar of the Eocene or Cretaceous limestones, at or below the falls could only be explained by a fault which, if present, would be easily recognised on the bare sides of the valley. The Kerka river is about 180 yards wide below the falls. The difference between the levels above and below them is generally stated as 170 feet; but it cannot be more than about 130 feet. The greatest height of any one fall is about 25 feet, and the water descends in many channels by a succession of cascades.

The first natural interpretation of the falls is that the valley above them had been cut down to its base-level; that the country has been

[1] F. von Kerner. *Der geologische Bau des mittleren und unteren Kerkagebietes*, Verh. k.k. geol. Reichs, 1895, p. 425.

recently uplifted; that this elevation gave the Kerka renewed powers of corrosion; and that the valley above Scardona had been deepened by the recession of the waterfall.[1] There is, however, no evidence for any recent uplift of this area of 130 feet; on the contrary, the evidence is all in favour of its subsidence.

The only rock apparent at the falls is calcareous tufa, which has

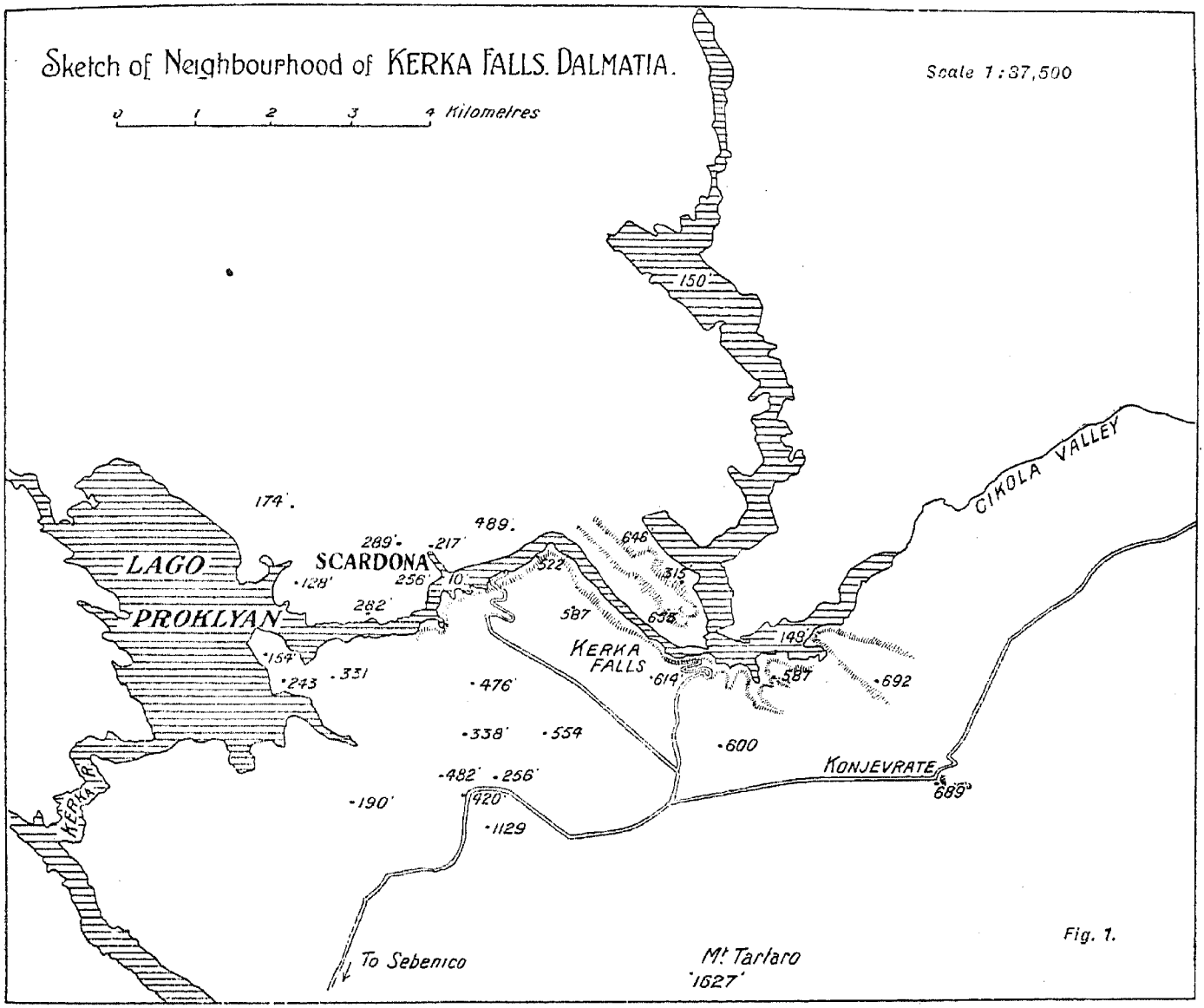

Fig. 1.

been deposited from the water (Fig. 1). Hence if the falls had receded, masses of this would formerly have existed up to the level of the top of the falls in the valley below them. Most of this tufa would have been destroyed during the recession of the falls, but some of it should have been left plastered on to the sides of the valley. No doubt there are occasional deposits of tufa, especially on the right bank, which is the less regular; but I did not see any tufa that could be regarded as adequate

[1] The view that the waterfall has helped to deepen the valley has been expressed by F. von Kerner. *Op. cit.*, Verh. k.k. geol. Reichs, 1895, p. 427.

remnants of the thick masses that must have existed had the waterfall receded south-eastward up the valley.

There is no indication in the valley below the falls of any rock barrier that has been slowly cut away; the valley there is nearly 600 feet deep and the total height of the falls is only 130 feet. Hence on the view that the falls have receded upstream, the valley must have been cut in two stages at different times. The walls of the valley, however, exhibit no signs of any such double period of erosion.

The valley below the falls, therefore, gives no evidence that they were ever situated further down-stream; and there is nothing at them available as a waterfall barrier except the tufa. But the existence of an old rock barrier above the falls is easily explained. The valley makes a sharp turn and crosses the strike of the rocks. It therefore cuts through the band of Eocene limestone, which forms the high ground along the right bank below the falls, and extends on the left back towards Konjevrate. This rock doubtless once formed some obstruction across the river; and as the water is rich in bicarbonate of lime, the disturbance caused by this obstacle would have occasioned the decomposition of the bicarbonate and the deposition of the carbonate of lime as calcareous tufa. The original obstacle would therefore be raised and opportunity for the formation of tufa increased. The continuation of the process would form the waterfall barrier, which would be steadily raised in height, and would slowly extend down the valley.

No doubt some destruction of the tufa goes on simultaneously with its deposition. Masses of tufa are formed as projecting shelves which break away when they become too heavy for their slight lateral support. The appearance of the falls, however, indicates that more tufa is deposited than is worn away. There is no undercutting at the base. On the contrary, the tufa projects at the foot of the cliff and the talus of fallen blocks contributes to the advance of the fall.

Above the falls the floor of the valley is a plain of alluvium, and about 600 yards upstream the valley subdivides into those of the Kerka and its tributary the Cikola; and both valleys are occupied by long fiord-like lakes; the Kerka lake extends for eight and a half miles to the north, and that of the Cikola for two miles to the east-north-east. These lakes are upheld by the tufa barrier. They and the alluvial plains beside them have therefore been formed by the waterfall.

As the tufa barrier is advancing down stream and is probably still being raised in height, the waterfall is tending to increase the length and depth of these lakes instead of gradually creeping toward them and destroying them by cutting through the embankment which upholds them.

2. The Topolje Falls.

The Topolje or Kerčić falls near the source of the Kerka river, two and a half miles east of the town of Knin, are less known and less accessible than the falls on the lower Kerka river at Scardona; but they afford especially clear illustration of the building up of a dam by waterfall action.

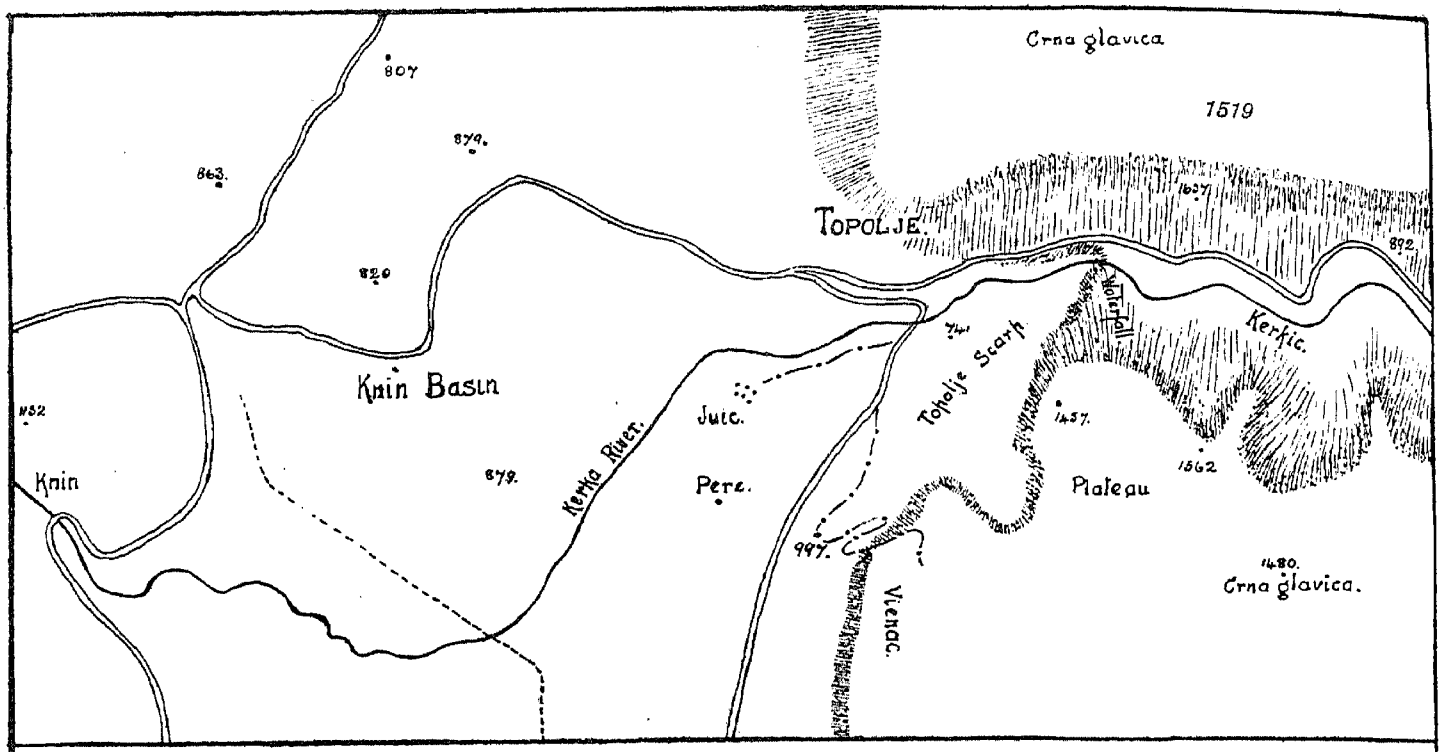

Fig. 2.

0 — 1/4 — 1/2 — 3/4 — 1 — 2 Kilometres.

Sketch Map Of Neighbourhood Of TOPOLJE Falls

Heights in feet
Scale 1: 37,500.

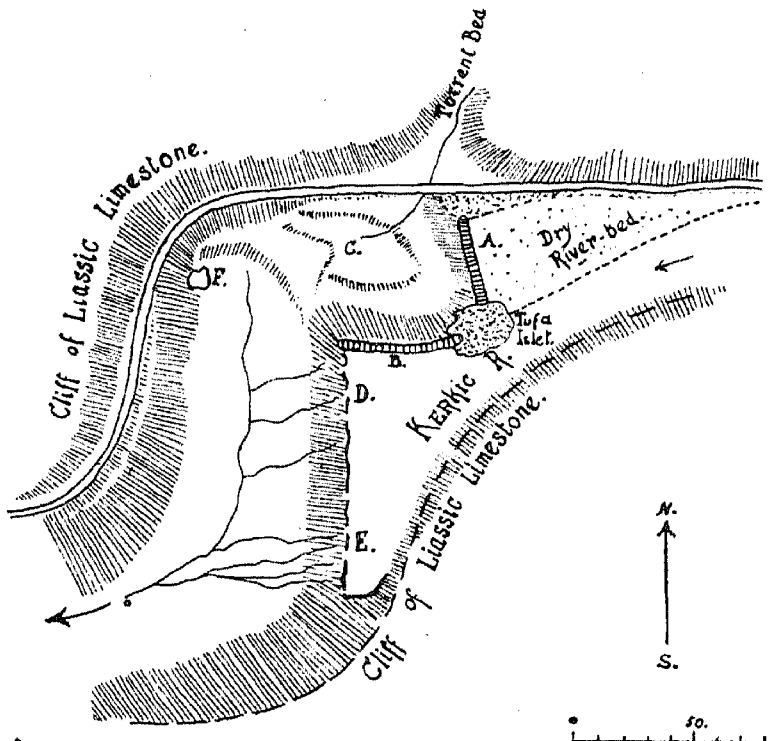

Fig. 3.

PLAN OF TOPOLJE FALLS.

AB. Artificial Embankments.

C. Northern Section Of Fall. - channel of torrent.

D. Central " " " .

E. Southern " " " . F. Fallen block of Limestone.

The uppermost source of the Kerka river is on Mount Dinara, whence in spring and winter the water flows through a deep sinuous gorge to the basin of Knin (Fig. 2). This headstream of the Kerka is known as the Kerkic or Kerčić. It falls near the village of Topolje into the basin of Knin, which is there bounded by a cliff of highly inclined and contorted Lower Lias limestones abutting on Triassic dolomites. The cliff at Topolje is probably a fault scarp, and in spite of the steep inclination of its beds the cliff has been cut off above into a plateau with a remarkably level surface.

The Kerčić gorge has been cut through this plateau, and at its mouth its floor is level with that of the Knin basin. The gorge is crossed about 500 yards from its entrance by a cliff of calcareous tufa about 70 feet in height. Above this cliff the Kerčić flows through a sinuous mountain valley, which has a flat floor covered by alluvium. The valley above the falls is said to be dry during the summer, and the Kerka river then rises at the foot of the falls; they are therefore often referred to as the source of the Kerka river. At the time of my visit (30th April 1911) the stream in the upper valley had so large a volume of water that the falls and spray could be seen from the hillside at Knin.

Approaching Topolje from Knin, my first impression was that the falls were due to the Topolje fault, and that they were originally level with the Topolje scarp and had been cut back to their present position by the ordinary processes of waterfall excavation. This view was all the more natural, as Dr. Schubert[1] has referred to a mass of tufa near the point where the footpath to Juic branches to the west from the main road, as due to a former fall of the Kerka; and he suggests that it is "probably the old Topolje fall." Sir Gardner Wilkinson[2] in 1848 said that "the rocks at the falls are furrowed into deep smooth channels," and he clearly regarded the furrows as due to the ordinary erosion which causes the recession of waterfalls. Closer examination soon revealed serious difficulties in this hypothesis.

The general plan of the falls is shown on Fig. 3 from a hastily prepared sketch-map. The cliff over which the river falls crosses the valley obliquely, so that the water is discharged into a gorge parallel to the main face of the fall, as in the great Victoria Falls of the Zambesi. During full flood the falls are divided in three sections. At the north-eastern end of the cliff is the bed of a torrent, which comes down from the hills immediately to the north; it discharges into the head of the lower gorge. At the time of my visit this torrent was dry.

The main volume of water then fell over the centre of the cliff near the point D in Fig. 3. The rest of the water falls in a series of small streams through gaps (at E) in the rim of the projecting southern end of the platform.

I approached the cliff expecting to find that it was a bar of some hard band of the Triassic or Liassic rocks which are well exposed on the

[1] R. Schubert. *Geologischer Führer durch Dalmatien*, 1909, p. 105.
[2] J. G. Wilkinson. *Dalmatia and Montenegro*, 1848, vol. i. p. 223.

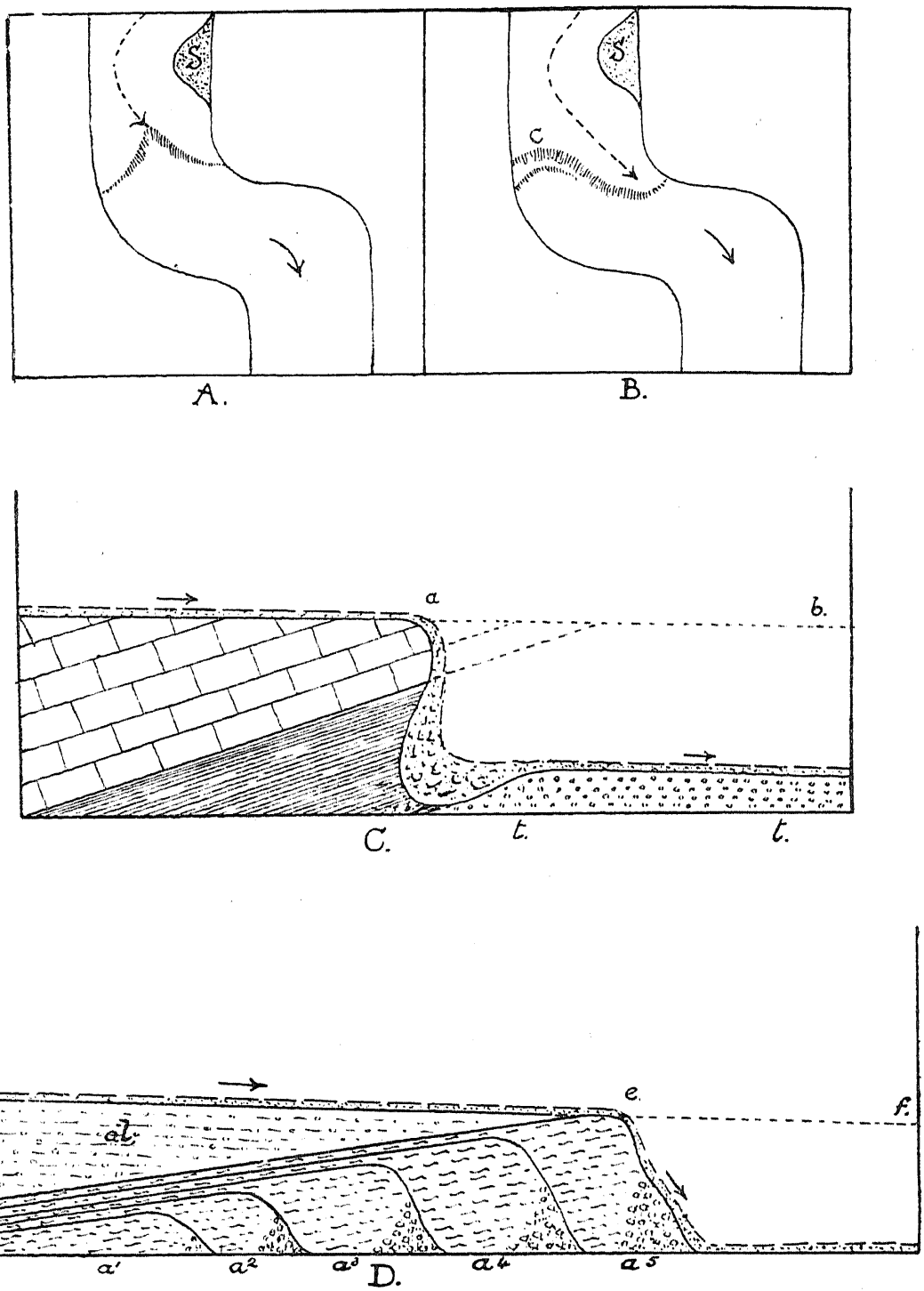

FIG. 4.—Diagrams Illustrating the Topolje Falls.

A. The Topolje Falls as they would have been if due to recession by waterfall erosion, with a notch at the centre of the fall. S=shoal.

B. Plans of the Falls: the barrier projects below the main fall and is notched where the waterfall is weakest, at *c*, where the cliff is replaced by some tufa terraces.

C. Section through an ordinary fall due to the undercutting of shale beneath a hard bed of limestone: the fall forms a deep pool, which shallows downstream owing to the talus bank *t* ; a, b, original level of the river below the fall.

D. Section through the Topolje Falls, a^1, the original tufa bar: a^2—a^5 the successive tufa bars: ~ ~ tufa: ° ° tufa-talus: *al.* alluvium: *e.f.* line along which there should be a tufa terrace if the waterfall had receded upstream.

bare cliffs on both sides of the gorge. I could, however, see none of these rocks *in situ* on the cliff forming the falls. Some blocks lying on the bottom of the gorge have fallen from the sides. All the rock exposed in the cliff is calcareous tufa; and that this material is not a thin crust covering Mesozoic limestone is clearly shown in the torrent bed (at C) on the northern side of the fall. Its channel shows a section 16 feet high of the rocks forming the cliff; but it has not exposed any of the Mesozoic limestone; the channel is cut through nothing but tufa of the usual many varieties, and calcareous sand. The whole waterfall cliff appears to consist of calcareous tufa.

I walked up the valley for a little distance above the falls, but saw no rocks *in situ* on the bed of the Kerčić. The river meanders across a plain of gravel and alluvium.

A further significant fact is the absence of calcareous tufa from the sides of the gorge below the fall. If the waterfall be slowly receding, then the platform above the falls must have continued to the Topolje scarp; and during its recession some of the calcareous tufa should have been deposited on the sides of the gorge. There is a little tufa immediately below the fall, but it is obviously due to the spray. There are also a few patches due to tributaries and springs; one such is cut through by the road on the right bank of the river, where the gorge widens out to the Knin basin; but the deposit is clearly due to a tributary which is now dry.

It may be suggested that the absence of tufa from the sides of the gorge below the falls is due to its having been removed by denudation; and though the material is much softer than the Mesozoic limestones it seems improbable that some patches should not have escaped destruction. Some traces of the old platform should remain as a terrace along the lower gorge, and some difference in weathering on the cliffs above and below the assumed former plateau might also be expected.

The shape of the falls moreover is the reverse of that of an ordinary receding waterfall, which is usually concave, the recession being most rapid in the centre of the stream where the volume is greatest and the cutting backward most powerful (Fig. 4, A and B). In the Topolje Falls, on the contrary, the cliff projects where the volume of water is greatest, as the deposition of tufa is most rapid there. The cliff is lowest, and there is a deep upstream notch where the water falls most rarely in the section fed by the torrent on the north bank. The largest fall of water has formed a projecting pier instead of a notch, and where the volume of water is least the barrier is lowest and most deeply notched.

It seems clear that the whole cliff is a bar of calcareous tufa deposited by the waterfall, and that this barrier is being slowly raised as it advances. The absence of tufa from the valley floor above the falls is probably due to its burial beneath the alluvium.

If this interpretation (Fig. 4, D) be correct, the Topolje Fall is being made by a dam which is advancing down-stream and leading to the formation of an alluvian plain behind it. The old gorge is being slowly filled up owing to the formation of the tufa bar, and when the falls have advanced a few hundred yards further, then the mouth of the Kerčić

valley will be flush with the Topolje cliff and the water will leap from a hanging valley on to the floor of the Knin basin.

3. The Pliva Falls at Jajce, Bosnia.

The stage to which the Topolje Falls are approaching has been reached by the picturesque falls at Jajce, the ancient capital of Bosnia, where the river Pliva, which overflows from the Jezero Lakes, in one leap of about 80 feet jumps from a hanging valley into the Urbas river. The Pliva Falls have a more complex geological history than either of the falls on the Kerka.

The geology of the neighbourhood of Jajce has been described and mapped by Dr. Katzer,[1] and an earlier account was published by Mojsisovics.[2] The falls are described in many books on Bosnia, but I am not aware that the following interpretation of their formation has been previously suggested.

The district around Jajce is a dissected plateau. The rocks to the north-east are Mesozoic limestones, which have been faulted against the Carboniferous and Permian rocks of the hills to the south-west. The Urbas has cut its way by three deep canyons through the ridges left by the dissection of the plateau. Most of the tributaries of the Urbas have cut their beds down to its level. Thus the Krezluk, the first tributary above Jajce, and the Ugar, which is below the town, are at the base level of the main river. The Pliva, on the other hand, flows through a hanging valley, the end of which actually projects over the stream of the Urbas. The height of the falls is recorded in Baedeker's *Guide* as 100 feet. According to Asboth[3] it is 90 feet; but he also states that the cliffs beside the Urbas are 90 feet in height, and as the Pliva Falls discharge through a notch in these cliffs one of his two figures must be incorrect. The height of the falls is between 70 and 80 feet, but as the Urbas was in flood, several feet may be added at the end of the summer owing to the lower level of the main river.

The Pliva at the bridge a little above the falls is about 80 yards wide, but at the falls the river is divided by many tufa islets, and the main fall on the northern side of the river is about 25 yards wide.

The Urbas is narrower and deeper than its tributary; it flows through a canyon cut along the strike of some Oligocene marls. The Urbas is only 20 yards wide a little above the falls, and its powerful stream impinges against the foot of the waterfall. There is a deep recess at the foot of the falls which may be one of the caverns so common in the tufa, or may have been worn out by the Urbas along a softer bed when the river was at a slightly higher level. Fresh tufa is being formed upon the face of the cliff, but the Urbas prevents its further advance by

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[1] Fr. Katzer. *Geologischer Führer durch Bosnien und die Hercegovina.* IX Internat. Geol. Congr. Serajevo, 1903, pp. 157-192.

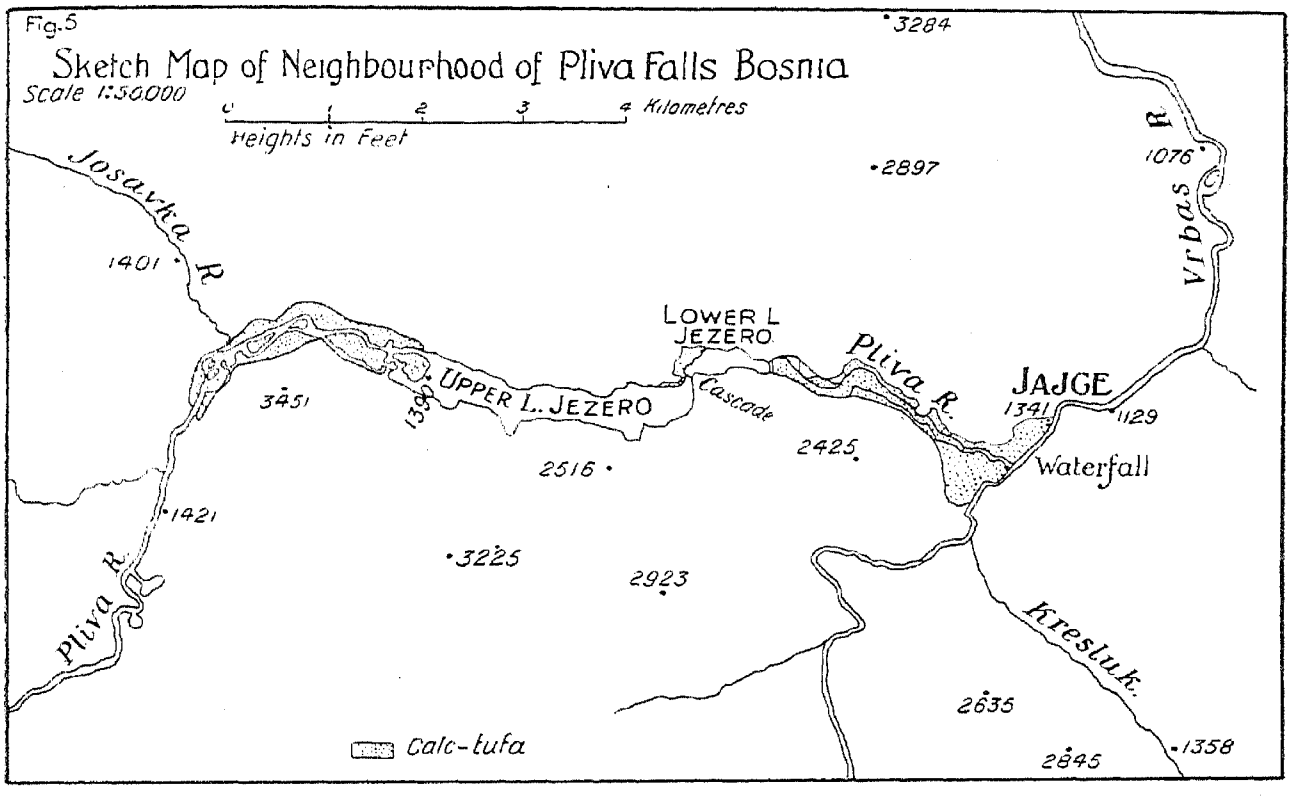
[2] E. von Mojsisovics. *Grundlinien der Geologie von Bosnien-Hercegovina.* Abh. k.k. geol. Reichs, 1880, vol. xxx. p. 225, 238-239.

[3] J. de Asboth. *An Official Tour through Bosnia and Herzegovina*, 1890, pp. 432-433.

constantly cutting away its base. Huge fallen blocks of tufa lie at the foot of the cliff.

The calcareous tufa of the falls is part of a mass which extends for nearly two miles along the valley of the Pliva. Its area is shown on Fig. 5 where it is inserted from Dr. Katzer's geological map. Its full thickness, according to Dr. Katzer, is 50-60 m. Most of the deposit is shown by two layers containing human remains to be pre-Neolithic. The lower of these layers is at the height of thirty-five metres above the level of the Urbas and at a few metres above the level of the Pliva. The upper bed is a few metres higher. Hence the uppermost 15 to 25 metres of the tufa were deposited in Neolithic and Post-Neolithic times.

Before the beginning of the deposition of the tufa the Pliva valley



was a gorge which, like the other rivers of the district, had been cut down to the base level of the Urbas; and the Pliva has since then filled up this gorge with calcareous tufa. The Pliva river was therefore dammed up, and the two Jezero lakes were formed; and at the same time the Pliva valley was converted into a hanging valley. After the tufa dam had been built to the height of from 50 to 60 metres above the Urbas, the Pliva has begun to excavate its bed and has cut a channel between the tufa crags on the north bank and the mound occupied by the Mohammedan cemetery on the south bank. The change from deposition to excavation is doubtless due to changes higher up the Pliva valley. This valley is crossed by three tufa barriers. The uppermost is at the western end of the Upper Jezero Lake; and extends along the main Pliva valley, but not along its tributary the Josavka. The floor of the upper Pliva therefore stands 20 feet higher than corresponding positions in the Josavka valley.

The second barrier divides the two Jezero lakes and forms the Upper Cascades of the Pliva.

The third tufa deposit is along the lower Pliva from near its outlet from the lower lake to its junction with the Urbas.

The Upper Lake Jezero is at the height of 1390 feet, the top of the Pliva Falls is at about 1210 feet, and the Urbas at the foot is at 1140 feet. The original summit of the tufa bar at the falls is about 1330 feet.

Before the formation of the two western tufa dams the lake in the Pliva valley would have been at the height of about 1330 feet. The level of this lake would have been gradually raised by the deposition of the tufa sheet along the course of the lower Pliva, until the lake stood at approximately the present level of the Lower Lake Jezero. The subsequent deposition of the second barrier then formed the Upper Jezero Lake, of which the water level is now at 1390 feet. Its surface is therefore about 60 feet higher than the top of the tufa barrier at the Pliva Falls. The raising in the level of the Jezero Lakes accordingly gave the Pliva a steeper slope and greater excavating power; and owing to this increase of its gradient, the Pliva has been able to cut its present channel through the old tufa bar. Thus the height of the falls has been lowered from about 120 to 70 feet. The raising of the level of the Jezero Lakes by the deposition of tufa barriers explains why the Pliva has in recent times partly cut through the barrier which it had previously built.

GEOGRAPHICAL NOTES

EUROPE.

Establishment of an Aërial Postal Service.—As a minor point of geographical interest, it is worth note that on Saturday, September 9, an aërial postal service was started between Hendon and Windsor, which is to be carried on daily, "weather permitting." The proceeds of the rather considerable postage are to be devoted to charity, so that the service cannot be said to be on a commercial basis, but its establishment is of interest in connection with the development of means of communication. Captain W. G. Windham, the most active mover in the present scheme, inaugurated the first aërial post in India last February.

ASIA.

Recent Volcanic Eruption in the Philippines.—The *Bulletin* of the Geographical Society of Philadelphia for July last contains two interesting articles on Taal, the volcano in the island of Luzon which was the seat of a violent eruption at the beginning of the present year.

The Philippines contain several active volcanoes, the most important of which are Apo, Mayon, and Taal. Apo is in the southernmost part of