REPUBLIEK VAN SUID-AFRIKA
REPUBLIC OF SOUTH AFRICA

DEPARTEMENT VAN MYNWESE

DEPARTMENT OF MINES

GEOLOGIESE OPNAME
GEOLOGICAL SURVEY

DIE GEOLOGIE VAN DIE SWARTBERGE, DIE KANGOVALLEI EN DIE OMGEWING VAN PRINS ALBERT, K.P.

TOELIGTING VAN BLAAIE 3321B (GAMKAPOORT) EN 3322A (PRINS ALBERT)

deur

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With a summary in English entitled:

THE GEOLOGY OF THE SWARTBERGE, THE CANGO VALLEY AND THE ENVIRONS OF PRINCE ALBERT, C.P.

Gedruk deur en verkrygbaar van die Staatsdrukker, Bosmanstraat, Pretoria.

Geologiese kaart in kleur op 'n skaal van 1:125,000 apart verkrygbaar teen 60c; oorsee 75c.

Printed by and obtainable from the Government Printer, Bosman Street, Pretoria.

Geological map in colour to a scale of 1:125,000 obtainable separately at 60c; overseas 75c.

terrasse op 40 voet en 70 tot 80 voet bokant die Gamka se loop. In Gamkapoort, noord daarvan, en noord van die Witberge is terrasse op 20, 40 en 60 tot 80 voet volop. 'n Uitgestrekte vroeëre oppervlak word op 40 voet bokant en weerskante van die Sandrivier (A. 3–4), en langs sy groot noordelike sytakke aangetref.

XIII. DIE KANGOGROTTE

Die Kangogrotte is in 1780 deur 'n skaapwagter van 'n sekere Van Zyl van die plaas Doornrivier, ontdek. Die grotte is geleë op die plaas Kombuys (B. 3) in die Kangovallei. Toe die plaas in 1828 van die hand gesit is, het die regering die grotte uitgehou en die plaaslike veldkornet gemagtig om toegangsfooie te vra. Sedert 1921 staan dit onder beheer van die Oudtshoornse munisipaliteit wat dit ontwikkel het tot 'n besienswaardigheid vir die publiek.

Die grotte is geleë in 'n kalksteenband in die Kalksteensone van die Kangoformasie. Die strekking van die kalksteenband is oos–wes en die helling steil. Volgens McIntyre (1932, p. 69–84) het die grotte ontstaan op 'n verskuiwingsone parallel met die strekking van die kalksteenband waarlangs ondergrondse water vryer kon beweeg en die kalksteen oplos. Die verskuiwingsone is omtrent 100 tree breed en verseël met 'n maaswerk van kalsiet wat in die dakke van etlike sale te sien is.

Mountain (1946a, p. 2–16) en King (1952) meld dat die ingang tot die grotte 1800 voet bo seespieël en sowat 'n 100 voet bokant 'n sytak van die Kangorivier is. Alhoewel daar op 'n paar plekke naby die ingang 'n steil daling in die vloer is, behou die Kangogrotte min of meer dieselfde hoogte en volg die strekking van die kalksteen (kyk fig. 1). Die direkte afstand van die ingang af na die Duiwel se Werkwinkel is sowat 'n halfmyl in 'n westelike rigting. Die gange kronkel so erg en is so onreëlmatig dat hulle sowat 2 myl lank is (kyk fig. 2). Die kamers is almal op dieselfde vlak en tot dusver is daar geen bewys van ander verdiepings of laer vlakke nie. Die drie grootste sale (Van Zyl se Saal, Botha se Saal en die Groot Saal) is van 200 tot 300 voet lank en 70 voet hoog, en word versier deur fantastiese stalagmiete, stalagtiete en heliktiete wat deurgaans in die grotte aangetref word. Samegroeiing van etlike stalaktiete gee aanleiding tot 'n gordynagtige groeisel wat baie in die grotte voorkom (kyk plate I en II). Die grotte is feitlik droog, die temperatuur sowat 18·3°C, en die lug vars.

Na aanleiding van die vorm van die Kangogrotte blyk dit dat die oplossing van die kalksteen deur freatiese water wat koolsuurgas bevat het, plaasgevind het toe die grotte in die sone van permanente versadiging gelê het. Te oordeel na die hoëterrasgruis wat die reste van die ou Middel-Tersiêre landoppervlak is, was die watertafel heelwat hoër as vandag en die gange en kamers vol water. Sedert daardie tyd het algemene styging van die land t.o.v. die seevlak die insny van die riviere in die omgewing verhaas, die watertafel het gesak en die grotte is gedreineer. Eers nadat die grotte drooggelê is, is kalsiumkarbonaat as druipsteen afgeset. Die karbonaat wat die druipsteen bou, is afkomstig uit deursyferende grondwater wat kalsiumbikarbonaat bevat.

Volgens King (1958, p. 45–54) kom 'n vetterige, rooi klei, afkomstig uit die verwering van die kalksteen, oral in die grotte voor. By die ingang was afsettings van sand en breksie wat op 'n geleentheid weggeskiet is. Uit die nabygeleë puin is twee groepe sandafsettings verkry: die ouere was fynkorrelrig, gesementeer en verbreek voordat dit in die latere ingesluit is.

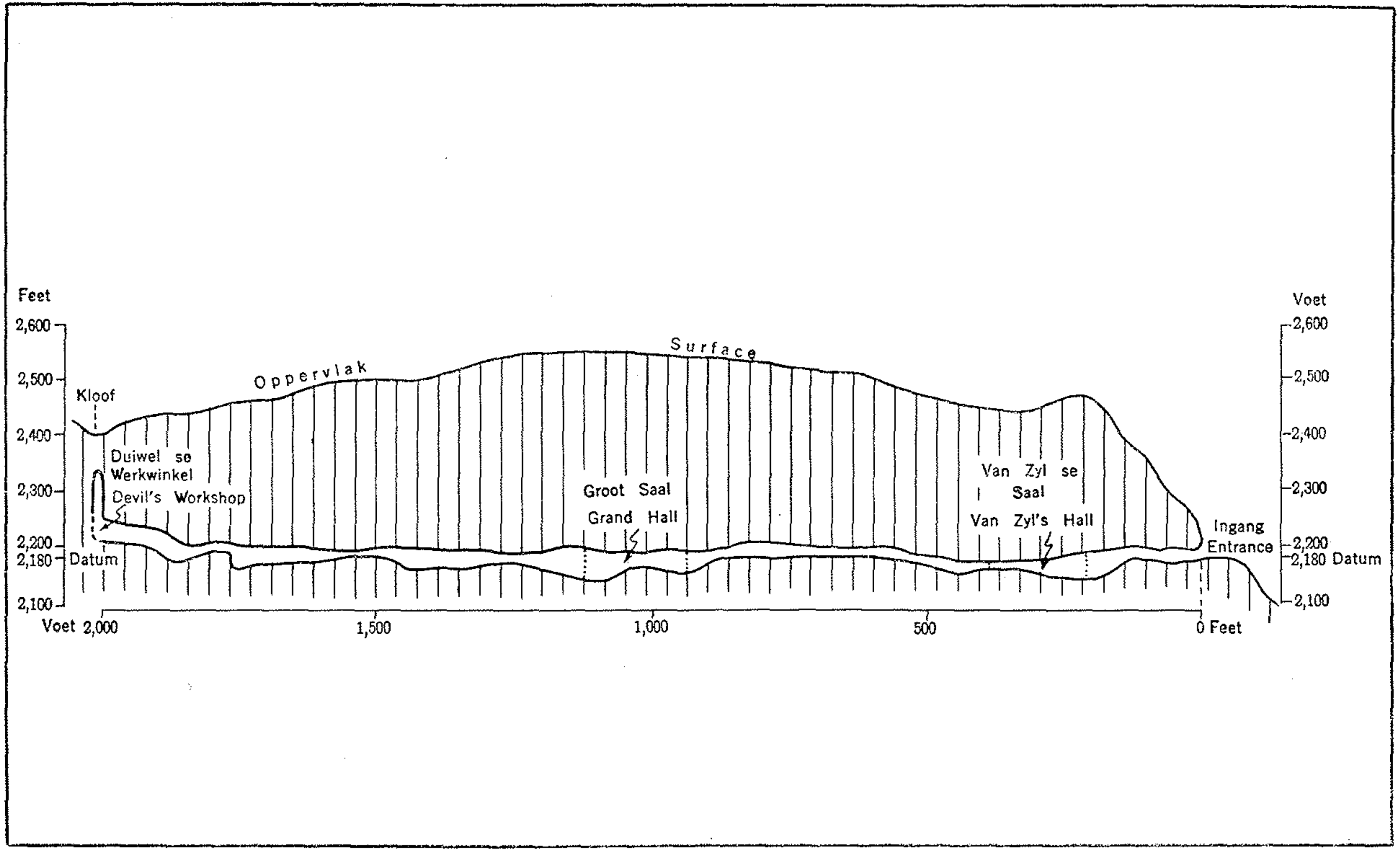

FIG. 1.—Ligging van Kangogrotte in verhouding tot landoppervlak (volgens die Suid-Afrikaanse Speleologiese Vereniging, met sekere wysigings).
Location of Cango Caves in relation to the land-surface (after the South African Spelaeological Association, with certain amendments).

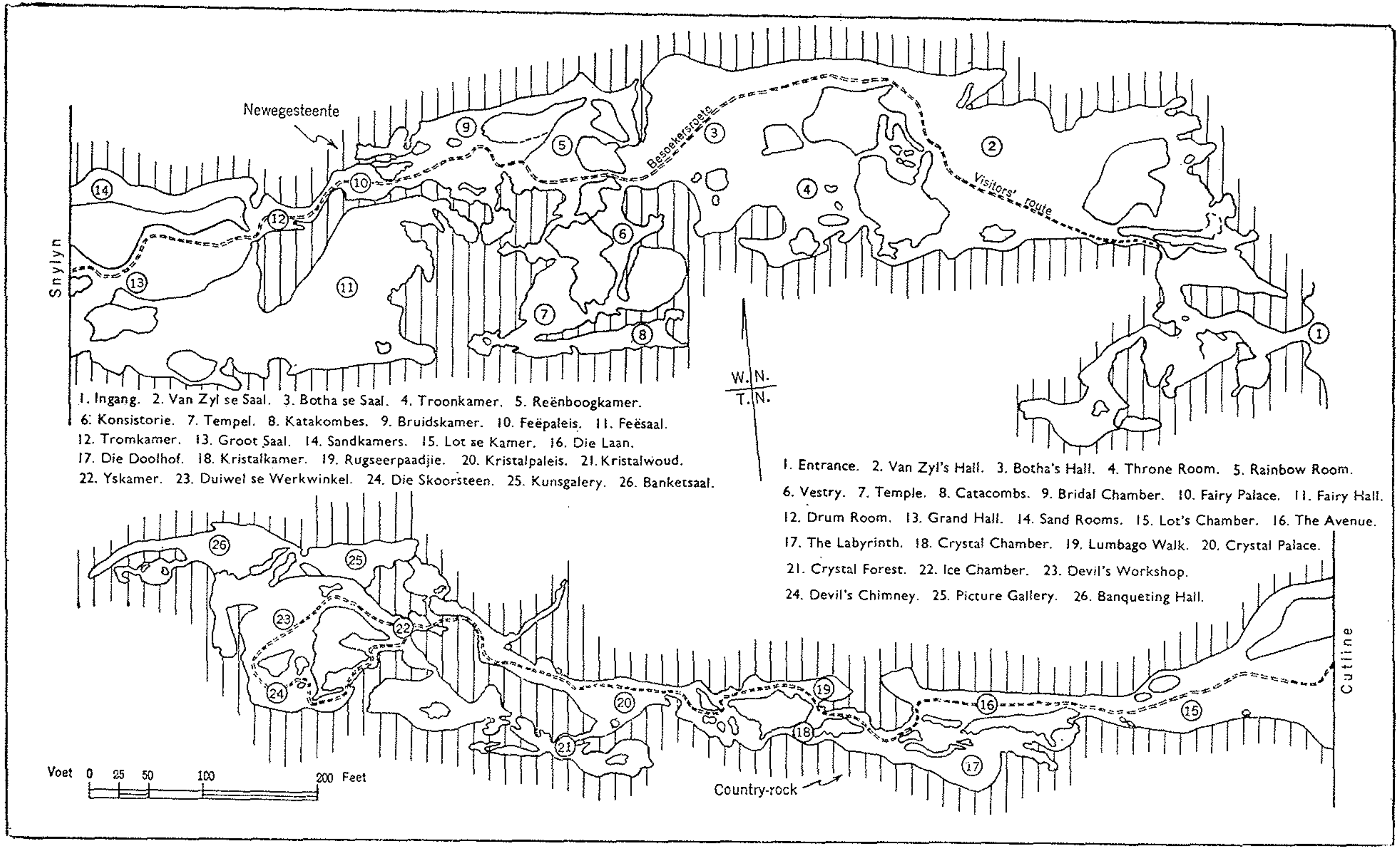

FIG. 2.—Plan van die Kangogrotte (volgens die Suid-Afrikaanse Speleologiese Vereniging, met sekere wysigings).
Plan of the Cango Caves (after the South African Spelaeological Association, with certain amendments).

FIG. 2.—Plan van die Kangogrotte (volgens die Suid-Afrikaanse Speleologiese Vereniging, met sekere wysigings).
Plan of the Cango Caves (after the South African Spelaeological Association, with certain amendments).

Laasgenoemde is 'n beenbreksie* soos dié van Sterkfontein en Makapansgat. Die sandafsetting is van tweërlei oorsprong, t.w. dié afkomstig uit die kalksteen en dié afkomstig van die Tafelbergsandsteen. Die waaisand van die Kalaharitipe kom nie hier voor nie. In vergelyking met ander grotte, is dierelewe tans skaars in die Kangogrotte. Versteende vlermuisbeendere is op een plek in die kalsietvloer ingesluit.

In die Kangovallei en in die omgewing van die Kangogrotte is nog etlike ander grotte aangetref (Walker, 1957, p. 11; Macpherson, 1958, p. 45–48). Een so 'n grot† is die „ Emerald Lake Cavern " wat omtrent 2 myl van die Kangogrotte af met die pad na Oudtshoorn geleë is. Alhoewel al lankal aan die inwoners bekend, is die opening in 1962 groter gemaak tydens padboubedrywighede. Soos ondersoek deur paddamanne en die Suid-Afrikaanse Speleologiese Vereniging in 1963 en 1964, word 'n kamer bereik op 'n diepte van bykans 70 voet d.m.v. 'n skag. Talryke gange en putte tot 60 voet diep waarvan die dakke 10 voet laer is as die stand van die water, sprei van hier uit. Een van die gange loop, nadat dit vir sowat 300 voet gevolg is, in 'n kolossale grot wat vol water staan en waarvan die bodem en wande nie vasgestel kon word nie. Miljoene gelling water vul hierdie grotte.

XIV. ONDERGRONDSE WATER

In die gedeelte noord van die Witberge, en in mindere mate ook in Die Gang en in die Kangovallei is water vir menslike gebruik, besproeiing en veesuiping gewoonlik afkomstig van boorgate. Die eerste pogings in die ou dae om gebruik te maak van ondergrondse water, het gelei tot die oopgrawe van fonteine. Deur die jare heen en met die gestadige toename van die bevolking, was fonteinwater nie meer genoegsaam nie, en is daar later oorgegaan tot die boor van gate op plekke binne in die fonteine. Boorgate van hierdie tydperk was maar van 60 tot 100 voet diep. Tussen die twee wêreldoorloë is daar al meer gate geboor as gevolg van verbeterde boerderymetodes en die toekamp van plase. Heel gou is gevind dat die watervlak daal en het boorgate van minder as 100 voet begin opdroog en moes hulle dieper geboor word na 150 voet en in die jongste tyd selfs tot meer as 200 voet.

Die reënval in die noordelike gedeelte is laag, die veld oop en die plantegroei laag en yl. Stroomgebiede van riviere bly die aangewese plekke om te boor, alhoewel die oop veld nie uitgesluit is nie. Naatstelsels en verskuiwings waarborg gewoonlik 'n goeie voorraad water in 'n landskap wat origens hard, vas en haas ondeurdringbaar is, en waarvandaan die afloop groot is.

Gereëlde watervlakpeiling‡ is tot dusver nog nie deur die Geologiese Opname in die gebied gedoen nie. Dit is egter welbekend van omliggende streke dat vanweë die uiters skraal grondbedekking, toestande vir aanvulling ten spyte van die geringe reënval, gunstig is. Reënwater vind feitlik onmiddellik sy weg na benede langs nate en laagvlakke—dit is nie nodig dat 'n dik laag grond eers tot veldkapasiteit gebring moet word nie.

Aan die anderkant is dit ongelukkig só dat die bergingsvermoë van die gesteentes baie beperk is. Water kan slegs in oop nate en laagvlakke opgaar; andersins is die gesteentes dig en ondeurlatend. Alhoewel grondwater dus baie vinnig na reëns aangevul word, kan boorgate baie maklik droog gepomp word.

*Kyk ook hoofstuk oor die argeologie van die Kangogrotte.

†Inligting goedgunstiglik verskaf deur mnr. R. B. Copley van die Suid-Afrikaanse Speleologiese Vereniging, Seksie Noord-Transvaal.

‡Bygedra deur mnr. J. R. Vegter van die Seksie Ondergrondse Water, Geologiese Opname.

Onderstaande gegewens van 'n boorgat naby Prins Albertweg, net noord van die gebied, is 'n goeie illustrasie van hoe lewering en watervlak kan wissel. Die boorgat self word nie gepomp nie, maar daar is 'n windpomp ongeveer 300 tree weg. Die naaste ander boorgate wat gepomp word, is ongeveer 'n driekwartmyl verwyderd.

Datum	Watervlakdiepte in voet	Lewering in g.p.u.
November 1951	110	500
Maart 1953	57·5	—
Oktober 1953	—	4200
November 1956	35·4	—
Junie 1961	±31	—

In die Swartberge word water uit fonteine verkry. „Waterklowe" voer die water na die neweliggende Kangovallei en Die Gang.

A. Waterdraende Eienskappe van die Gesteentes

1. Die Kangolae

Met 'n gemiddelde reënval van 400 mm (16 duim) in die Kango wat te min is vir droëlandboerdery, is die bewoners afhanklik van ondergrondse voorrade. 'n Hele paar standhoudende riviere ontspring in die Tafelbergsandsteen aan die suidelike hange van die Swartberge en vloei deur die Kango. In die somermaande is die water swak en voldoen verreweg nie aan die eise vir besproeiing wat die redelik digbewoonde, vrugbare valleie stel nie. Uit die bestaande state blyk dit dat sowat 50 persent van die boorgate òf geen water het nie òf 'n lewering het van minder as 100 g.p.u.

(a) *Die Kalksteensone*

Die meerderheid boorgate in hierdie sone is in die digbevolkte Kangovallei geboor. Die gesteentes bestaan uit skalie met kwartsitiese en veldspatiese grintsteenbande en kalksteen, en is gewoonlik so fynkorrelrig en kompak dat hulle swak waterdraers is. Selfs die grintsteen is byna ondeurdringbaar vir water as gevolg van sementering deur sekondêre minerale. Die kalksteen is kompak en ondeurlaatbaar. 'n Goeie lewering kan egter verwag word as nate of grotte met water raakgeboor word. Die water word vir besproeiing en huishoudelike doeleindes gebruik. Die water van omtrent 'n derde van die boorgate kan as „ goed " beskryf word, die res as „ brak " of „ sout ". 'n Analise (I) van water uit 'n boorgat in die kalksteenband by die Kangogrotte word in onderstaande tabel aangegee. Die sterkste boorgat (221 voet diep) is op Voorbedagt (B. 3) geleë en lewer 5070 g.p.u. Alhoewel water al op 104 voet gevind is, is die sterkste lewering by 175 voet. Die rushoogte van die water is 73 voet van bo af. Sowat 2200 g.p.u. ontspring op 'n diepte van 625 voet in 'n diep boorgat van 675 voet, net oos van die Kangogrotte. Die water is in die kalksteen by die kontak met 'n skalieband aangetref. Sowat die helfte van die boorgate in hierdie sone is òf droog òf lewer 100 gelling en minder per uur. In figuur 3 word die diepte waar water getref is in 32 boorgate, en die lewering per uur in 25 boorgate, grafies aangegee.

(b) Die Onderste Grouwaksone

Hierdie sone is gebou uit sandige skalie, subgrouwak en arkose—almal fynkorrelrig en syferdig vir water. Hierdie kenmerke verklaar waarom sowat 45 persent van die boorgate mislukkings is of minder as 100 g.p.u. lewer. 'n Matige lewering kan egter verwag word as gate in afwisselende sandige en kleiige bande geboor word. Die water van sowat 'n derde van die boorgate word as „ brak ", „ sout " en „ onbruikbaar " beskryf; die res lewer water wat as „ drinkbaar ", „ vars " en „ goed " bestempel word.

Besonderhede betreffende die diepte waar water in 47 boorgate gevind is en die lewering per uur in 43 gate, word in die grafiese voorstelling in figuur 3 aangegee.

(c) Die Kruisgelaagde Grintsteensone

Baie min gate is in hierdie sone geboor omdat dit in die ranterige en onbewoonde gedeelte van die Kango voorkom. Die sone is sandig en die grofkorrelrige kwartsiet en die konglomeraat behoort goeie waterdraers te wees. Op die plaas Welgevonden (B. 2) is 'n gat in die formasie naby die kontak met die onderliggende Grouwaksone geboor. Dit is 262 voet diep, en die kontak is op 228 voet deurgegaan waar 1690 g.p.u. raakgeboor is. Die water styg tot 16 voet van bo af en is effens kruiterig.

By wyse van opsomming kan vermeld word dat dit 'n waagstuk is om in die Kangolae te boor, aangesien die gesteentes gewoonlik so fynkorrelrig en ondeurlatend vir water is. Die persentasie sukses kan verbeter word deur boorplekke op meer wetenskaplike maniere te kies.

2. DIE KAAPSISTEEM

(a) Die Tafelbergserie

Hierdie serie is grotendeels opgebou uit kwartsitiese sandsteen wat deur nate in alle rigtings gekruis word, en is besonder waterryk. Die feit dat dit berge vorm en dus in 'n sone van hoë presipitasie lê, verseker gereelde aanvulling. Alhoewel die fonteine in hierdie gesteente oor die algemeen standhoudend is, verminder die vloei tog in die warm somermaande en kan selfs gaan staan. Veelvuldige vars strome, klein en groot, vloei uit die berge en maak die „ waterklowe " uit wat nabygeleë plase en selfs Prins Albert en Oudtshoorn van water voorsien. Op plekke is die water ligbruin gekleur weens die teenwoordigheid van organiese materiaal.

(b) Die Bokkeveldserie

Die bewoners van plase op die hoof Bokkeveldvoorkomste is in baie gevalle afhanklik van die bergstrome uit die Tafelbergserie vir hulle water. Aangesien die water baie verswak in die somer en omdat party plase weg van die bergstrome lê, is gate geboor vir besproeiing en veesuiping. Baie van die boorgate is langsaan die vloedvlaktes van riviere, en ook onderkant puinwaaiers waar die skalie redelik verweer is en gereeld aangevul word. Op 'n paar plekke is water raakgeboor op die kontak tussen sandsteen en skalie van die onderste drie sandsteen- en skaliesones van die Bokkeveldserie. Wat die gehalte betref, is die water redelik vars; in die boonste Bokkeveldskalie is die water op plekke effens brak tot taamlik sout. In baie gevalle is die water hard en soms ietwat kruiterig.

Die dieptes waar water getref is in 92 boorgate, en die lewering per uur van 38 boorgate, word deur die grafiese voorstelling in figuur 4 weergegee.

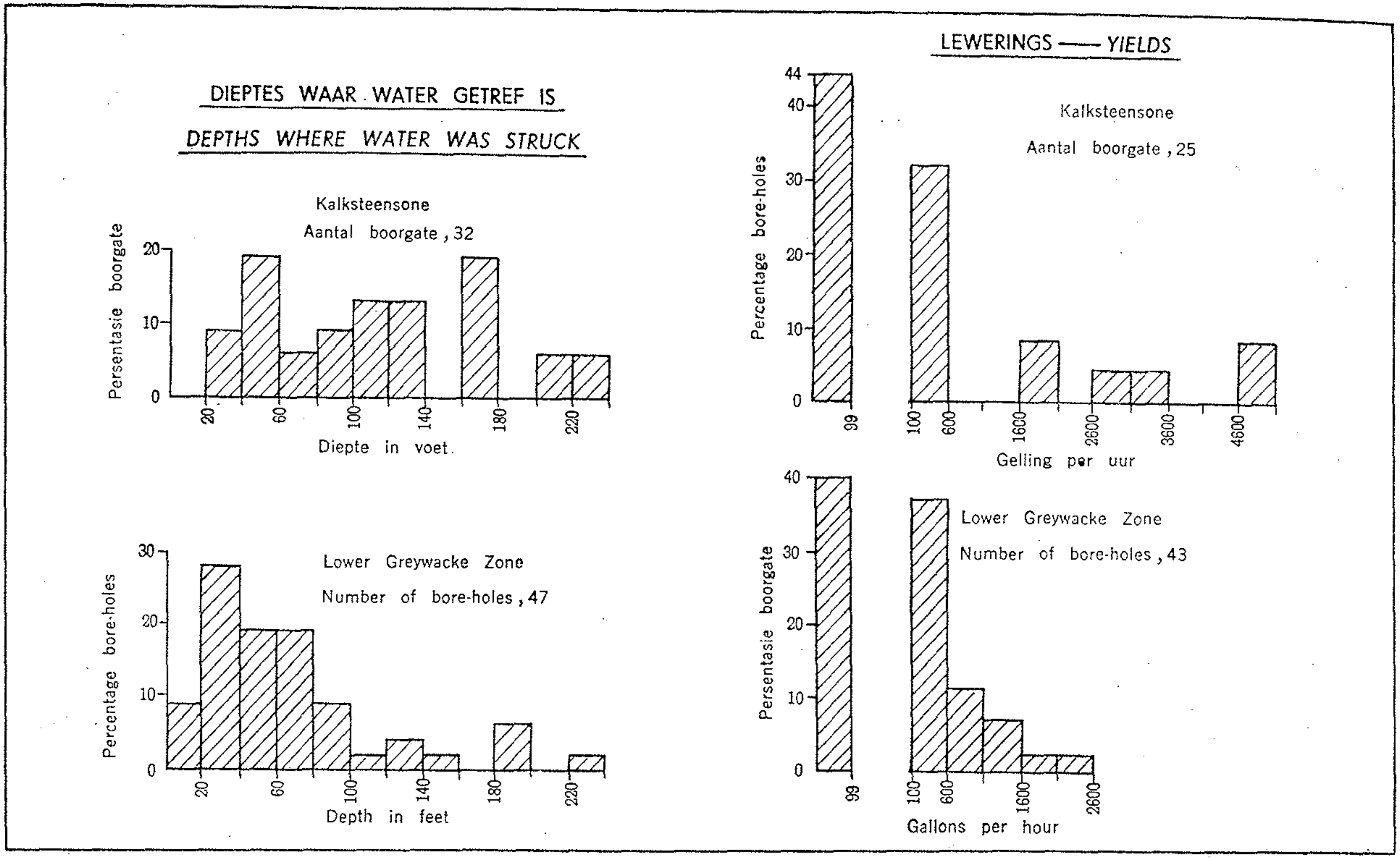

FIG. 3.—Gegewens van boorgate in die Kangoformasie.
Data of bore-holes in the Cango Formation.

Geen gate is in die Bokkeveld van die Gamkaskloof (B. 1–2) geboor nie omdat water verkrygbaar is uit die bergstrome wat uit die Tafelbergsandsteen vloei. Op die plaas Opzoek (B. 1) het etlike diep boorgate, een meer as 300 voet diep, nie daarin geslaag om genoegsaam water te kry nie.

(*c*) *Die Wittebergserie*

Oor die algemeen gesproke is die skaliebande baie swak waterdraers en is daar talle droë gate geboor soos bv. op Bloemendaal, Vrisch Gewagt (B. 4) en verder na die ooste. Suksesse is behaal in boorgate in, of net noord van die basale kwartsiet net bokant die Bokkeveldlae en tussen die kwartsietbande hoër op in die opeenvolging. Die kanse op redelike vars water en brak water is omtrent ewe veel. In etlike gevalle, veral in die voormalige Onder-Dwykaskalie wat nou by die Witteberg ingedeel word, is die water kruiterig.

'n Grafiese voorstelling van die dieptes waarop water in 50 boorgate getref is, word in figuur 4 weergegee. 'n Ontleding van Prins Albert se drinkwater (II) wat afkomstig is uit die Kaapsisteem, word in die tabel hieronder aangegee.

	I (mg per liter)	II (mg per liter)	III (mg per liter)
$Na^{\cdot}$	26	13	166
$K^{\cdot}$	—	—	—
$Mg^{\cdot\cdot}$	59	9	66
$Ca^{\cdot\cdot}$	8	nul	126
$Al^{\cdot\cdot\cdot}$	—	—	—
$Fe^{\cdot\cdot}$	—	—	—
Totaal van katione	93	22	358
F'	0.2	0.3	0.6
Cl'	25	20	280
NO_2'	negatief	negatief	nul
NO_3'	nul	nul	130
SO_4''	14	11	144
HCO_3'	329	31	360
CO_3''	nul	nul	nul
Totaal van anione	368.2	62.3	914.6
$NaHCO_3$	13	nul	nul
Na_2CO_3	nul	nul	nul
Tydelike hardheid as HCO_3'	128	25	295
Permanente hardheid as $CaCO_3$	134	10	290
Soutammoniak	nul	nul	nul
Albuminoïed ammoniak	0.01	0.05	0.01
pH	7.1	8.15	7.8
Suurstof opgeneem (4 uur by 27°C)	0.17	0.93	0.21
Dioniese geleidingsvermoë by 20°C (mho—cm × 10^6)	500	130	1600
Totaal opgeloste vaste stowwe by 105°C	341	38	1032

I. Water uit 'n boorgat by die Kangogrotte. Monster P 566/53 ontleed deur P. R. B. Heymann. Gepubliseer met die toestemming van die Munisipaliteit van Oudtshoorn.

II. Water uit die munisipale reservoir, Prins Albert. Monster P 48914 in 1951 ontleed deur E. Smith. Gepubliseer met die toestemming van die Munisipaliteit van Prins Albert.

III. Water uit 'n boorgat in Dwykatilliet, Prins Albert. Monster W 360/56 ontleed deur G. A. Roux.

Ontledings deur die Navorsingsinstituut vir Grond (voorheen Skeikundige Diens), Pretoria.

FIG. 3.—Gegewens van boorgate in die Kangoformasie.
Data of bore-holes in the Cango Formation.

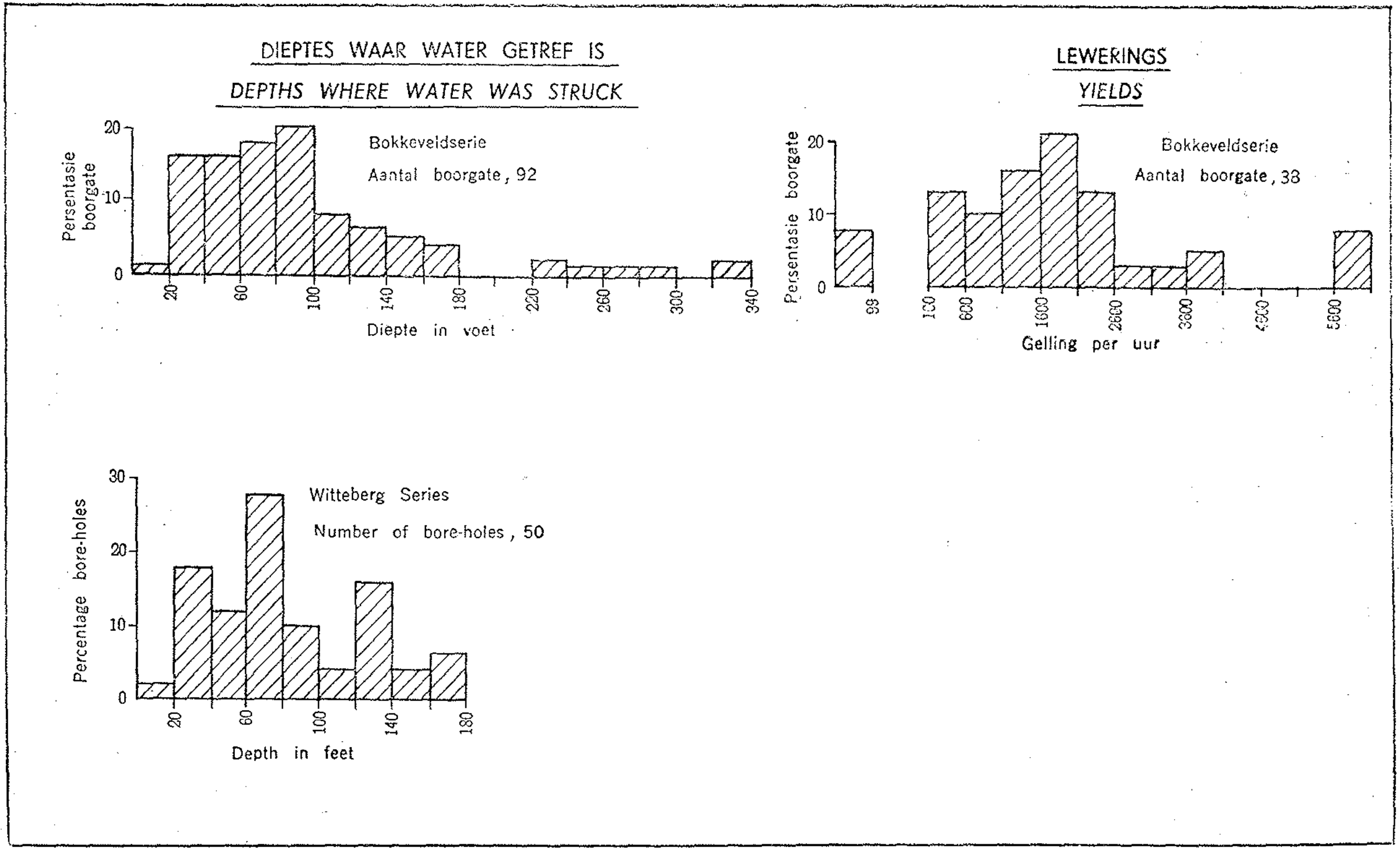

FIG. 4.—Gegewens van boorgate in die Kaapsisteem.
Data of bore-holes in the Cape System.

3. DIE KAROOSISTEEM

(*a*) *Die Onder-Dwykaétage*

Die Dwykatilliet is 'n heterogene gesteente wat geen gelaagdheid besit nie; ondergrondse water kom in nate en krake voor. Op Groote Tyger Berg (A. 4) is waargeneem dat syferwater uit horisontale nate vloei. As die tilliet vars en onverweer is, boor dit hard sodat daar op plekke min vordering met 'n stampboor per dag in sulke boorgate is. As die boorpunt in nate beland, gaan die boordery makliker en word daar op plekke water aangetref. Wat die gehalte betref, is die water in meer as die helfte van die boorgate wat waargeneem is, brak, en selfs sout op plekke. In 'n paar gevalle was die water kruiterig. Op een plek was dit so erg dat „ kruitvesels " pype toekoek. In etlike gevalle het die water so min vaste stowwe bevat dat dit byna kon deurgaan as vars. 'n Ontleding van water (III) uit 'n boorgat in die tilliet waar die enigste aanvulling deur middel van reën is, word aangegee.

Gegewens omtrent die diepte waar water aangetref is in 27 boorgate, word in die grafiese voorstelling op voublad 1 uiteengesit.

(*b*) *Die Bo-Dwykaétage*

Weens die teenwoordigheid van die groot verskeidenheid van gesteentes in die Bo-Dwykaskalie, is daar baie boorgate op hierdie étage geboor. Afgesien van baie droë boorgate en ook putte is daar tog suksesse. Water word op baie plekke raakgeboor by die kontak tussen die skalie en die onderliggende tilliet in diepte. In die meerderheid gevalle is die ondergrondse water van hierdie band kruiterig. Dit is moontlik te wyte aan die teenwoordigheid van piriet veral in die Witband. Brak water word in baie boorgate aangetref. In die grafiese voorstelling op voublad 1 word die diepte waar water in 22 boorgate aangetref word, aangegee.

(*c*) *Die Onder-Eccaétage*

Dit is net soos die Bo-Ecca- en Onder-Beaufortétage opgebou uit 'n afwisseling van sandsteen- en skaliebande; in laasgenoemde twee étages egter is die afwisseling van sandsteen en skalie egaliger. In die westelike gedeelte van Katriver & Sand Vlakte (A. 2) langs die Katrivier, is sterk water raakgeboor in twee boorgate op 'n verskuiwing waarvan die verskuiwingslyn aangedui word deur kalsietare. Die boorgate is oopgegrawe in 'n fonteinsloot waarlangs die standhoudende water vloei. Omtrent die helfte van die boorgate in hierdie étage lewer byna vars water. Die water uit 'n derde van die boorgate word as „ effens brak " bestempel. Sowat 15 persent van die boorgate het kruiterige water. In net een geval is die water as „ sleg " bestempel en in nog 'n geval het die water sleg geruik as gevolg van 'n oormaat kruit. Die diepte waar water getref is in 67 boorgate, word in die grafiese voorstelling op voublad 1 weergegee.

(*d*) *Die Middel-Eccaétage*

Uit die state van meer as 50 boorgate in hierdie étage wat hoofsaaklik uit skalie bestaan, blyk dit dat die oorgrote meerderheid dieper as 100 voet is. Waar die diepte omtrent 20 jaar gelede minder as 100 voet was, het die water ingegee en moes die gate verdiep word. In 'n paar boorgate op Botterkraal van Carolus Kraal & Jansens Kraal (A. 4) wat langs 'n rivierloop geleë is, is die eerste water op minder as 50 voet aangetref. Boorgate is oor die algemeen standhoudend. Die gehalte van die water word in die meeste gevalle as „ vars " beskryf, in 'n paar gevalle as „ brakkerig " en in nog ander gevalle as „ kruiterig ". Die grafiese voorstelling op voublad 1 gee die besonderhede van die diepte waar water getref is in 59 boorgate en die lewering per uur van 21 gate.

(e) Die Bo-Ecca- en Onder-Beaufortétage

Hierdie twee étages is albei opgebou uit sandsteen- en moddersteenlae en het min of meer eenderse eienskappe wat die voorkoms van ondergrondse water betref. Volgens sowat 120 boorgate in hierdie gesteentes blyk dit dat die water in die meeste gevalle net effens brak is. Alhoewel water hier en daar as „ kruiterig " of „ brak " beskryf word, is dit byna sonder uitsondering geskik vir menslike gebruik. Die hoeveelheid wissel van 'n sogenaamde „ veewatertjie " (d.w.s. 100 en minder g.p.u.) tot gate met meer as 4000 gelling per uur. Op plekke is die sterkere gate so standhoudend dat die water deur middel van turbines gepomp word. In baie gevalle het water van boorgate minder geword en in 'n paar gevalle selfs ingegee. 'n Ontleding van water uit 'n boorgat in die Beaufortlae by Prins Albertweg, net benoorde die gebied, word in die tabel hieronder gegee. Die diepte waar water getref is in 177 boorgate, en die lewering van 41 boorgate word in die grafiese voorstelling op voublad 1 aangedui.

Op verskeie plase is daar nog fonteinslote te sien waarin daar na ondergrondse water gegrawe is en teen die skuinste na die oppervlak gebring is. Alhoewel die meerderheid fonteine weens die dalende watertafel opgedroog het, bestaan daar nog 'n paar kontakfonteine op Badsfontein (A. 1) en op Virginia van Klipfontein (A. 2). In al hierdie gevalle word die ondergrondse water deur „ keerbanke " met 'n helling teen die vloeirigting van die water opgedam. Hierdie fonteine bevat op een na wat vars is, almal kruitwater.

Monsternommer	294* (Bond, 1947, p. 144)
Dele $CaCO_3$ per 10^6 water	
Metieloranje-alkaliniteit	237
Totale hardheid	332
Permanente hardheid	95
Tydelike hardheid	237
Hardheid aan Ca-soute toe te skrywe	232
Hardheid aan Mg-soute toe te skrywe	100
Soda-alkaliniteit	nul
Dele per 10^6 water	
Totaal aan vaste stowwe by 106° C	590
Silika (as SiO_2)	26
Fluorides (as F)	0.1
Nitriete	nul
Nitrate (as NO_3)	8
Chlorides (as Cl)	138
Sulfate (as SO_4)	116
Kaliumsoute (as K)	Minder as 5
pH-waarde	7·5

*Monster 294 is afkomstig uit 'n boorgat in die Onder-Beaufortétage by die spoorwegstasie op Prins Albertweg.

Monsternommer	294* (Bond, 1947, p. 144)
Persentasie van totaal aan vaste stowwe	
SiO_2	4·3
CaO	21·6
MgO	(6·7)
Cl	23·0
SO_4	19·4
Soda-alkaliniteit (as Na_2CO_3)	nul
Totale hardheid (as $CaCO_3$)	56·0
Permanente hardheid (as $CaCO_3$)	16·0
Tydelike hardheid (as $CaCO_3$)	39·7
Verhouding CaO:MgO	1: 0·32

*Monster 294 is afkomstig uit 'n boorgát in die Onder-Beaufortétage by die spoorwegstasie op Prins Albertweg.

4. DIE KRYTSISTEEM

(*a*) *Die Enonétage*

Die konglomeraat in hierdie étage is byna syferdig as gevolg van die kleiige matriks. Bykans 65 persent van die boorgate is mislukkings of lewer minder as 100 g.p.u. Suid van die gebied kom daar sandsteenbande in die Enon voor, en hulle is goeie waterdraers. Alhoewel die water uit die Kryt gewoonlik brak is in mindere of meerdere mate, is dit drinkbaar. Die gruis in ou rivierbeddings van Krytouderdom lewer goeie voorrade, bv. dié op Quarrieveldt (B. 1) naby Calitzdorp lewer 3380 g.p.u.

'n Boorgat (348 voet diep) op Buffels Bosch Rivier (B. 3) het op 'n diepte van 240 voet deur die verskuiwingsvlak gedring en 2028 g.p.u. getref. Die water staan 58 voet van bo af. Die grafiese voorstelling in figuur 5 gee besonderhede van die diepte waar water gevind is in 25 boorgate en die lewering van 18 boorgate in die Krytlae.

5. TERSIÊRE TOT RESENTE AFSETTINGS

Putte word nog hier en daar aangetref veral in die ongekonsolideerde puin langs lope en riviere. Met die steeds sinkende watertafel het baie van hulle opgedroog. In die vloedvlakte van die Grobbelaarsrivier by Schoemanshoek van Roodewal (B. 3) is etlike putte gegrawe. In baie gevalle lewer hulle 'n redelike hoeveelheid syferwater. Vyf van hierdie putte is gemiddeld 40 voet diep, lewer gemiddeld 240 gellings per uur en staan gemiddeld 16 voet van bo af. Die water is op 'n diepte van omtrent 30 voet aangetref.

Die gruisvulsel in party van die noordvloeiende riviere uit die Swartberge soos bv. by Prins Albert en Weltevrede (B. 2), kan groot hoeveelhede water bevat. Dit beteken dat, al het die riviere reeds gaan staan aan die oppervlak, hulle nog ondergronds vloei. Prins Albert se oorspronklike watervoorraad (kyk ontleding II onder „Ondergrondse Water") was afkomstig uit hierdie bron en is tot 'n mate opgedam deur die harde Wittebergkwartsiet net suid van die dorp. Die opdamming word aangehelp deur ondergrondse betonmure. Die beginsel van ondergrondse vloeiing geld ook vir die groot riviere bv. die Dwyka en Gamka. Tydens die uitgrawings vir die fondamente vir die nasionale padbrug oor die Dwyka, moes groot

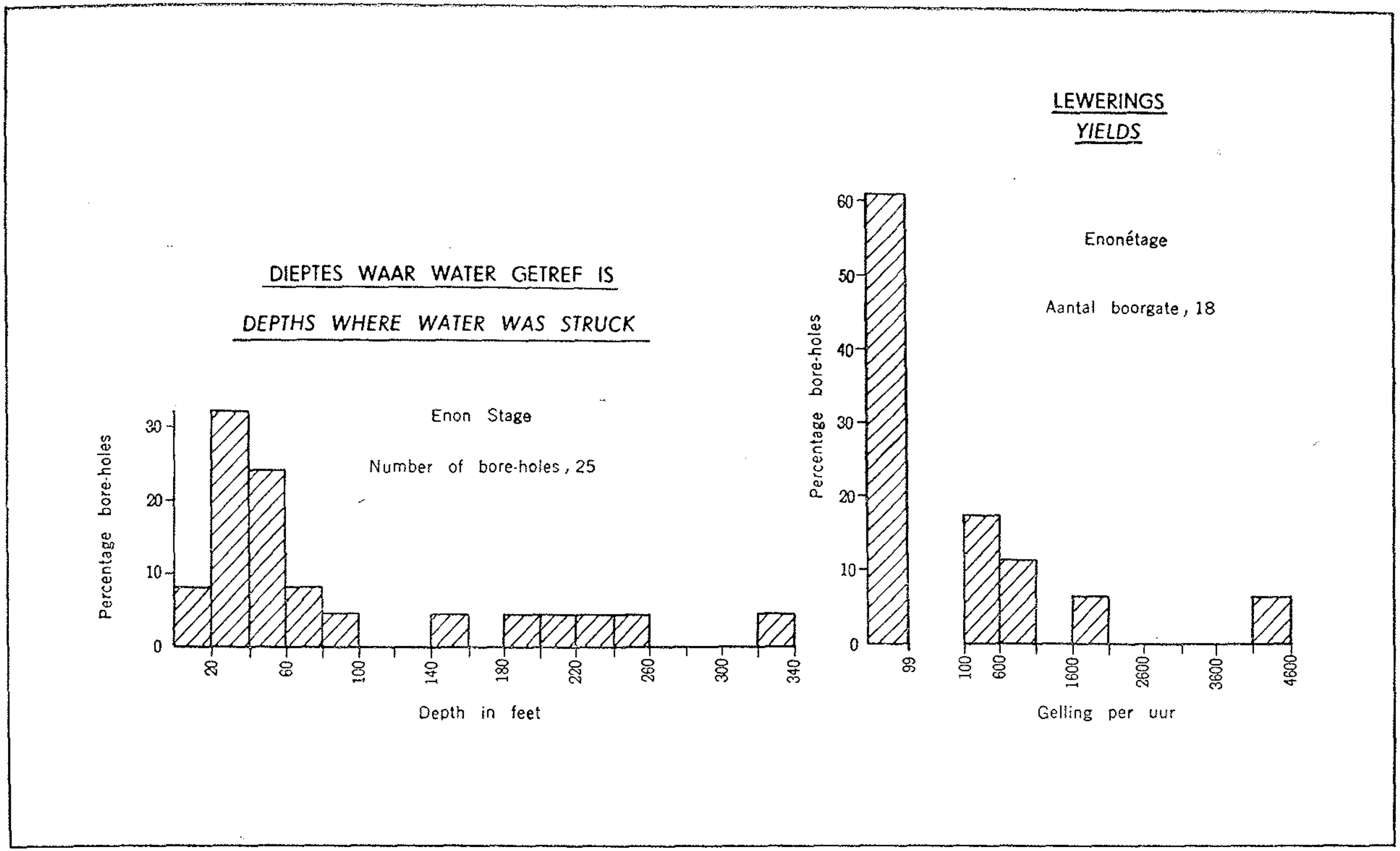

FIG. 5.—Gegewens van boorgate in die Krytsisteem.
Data of bore-holes in the Cretaceous System.

hoeveelhede water uitgepomp word. As die water nog redelik hoog in die sandbedekking van die bodem loop, kan dit bekom word in vlak sandputte of in gorês wat selfs diere in die sand grawe.

XV. EKONOMIESE GEOLOGIE

A. Boumateriaal

Verskeie van die formasies in die gebied lewer bousteen vir plaaslike gebruik. Die bruinerige en wit kwartsiet van die Wittebergserie (Witstreep), en ook die Witbandchert van die Bo-Dwykaskalie word baie keer weens hulle hardheid en plat vorm aangewend vir die bou van fondamente vir woonhuise, buitegeboue en krale. Die chert het die voordeel dat dit met min afwerking geskik is om mee te bou. Die plaveisteen van die Witteberg en die grys lei van die Bo-Dwykaskalie word op baie plekke vir bestrating gebruik. Op plekke word die sandsteen van die Onder-Eccaétage deur nate op so 'n manier gesny dat dit as langwerpige blokke verweer. Sulke blokke word as bousteen gebruik en in die verlede is die langwerpiges ook as heiningpale aangewend.

Wybergh (1920, p. 60) maak melding van 'n groot massa, egalige, liggekleurde kalksteen op Rust en Vriede (B. 4) wat as bousteen gebruik kan word. Hierdie voorkoms maak deel van die Kangoformasie uit.

Die wit Wittebergkwartsiet is uitstekend geskik vir verbreking tot beton- en padaggregaat. Spoelsand afkomstig van die Witteberg- en Tafelbergserie, alhoewel nie baie hoekig nie, is as bousand te verkies bo dié afkomstig uit die Ecca- en Beaufortserie omdat laasgenoemde te veel kleiigheid bevat.

B. Fosfaat

Konkresies en lense van fluoorhoudende kalsiumfosfaat word in drie sones in die donker skalie van die onderste gedeelte van die Bo-Dwykaskalie, aangetref. Die onderste sone kom in die skalie net bokant die tilliet voor. Die konkresies is lensvormig, tot 12 duim dik en 20 voet lank, en verweer maklik uit die omringende skalie. Op baie plekke is daar een of twee lense ligblou fosfaat net bokant die rooierige chertlagies. In die middelste sone is die konkresies byna rond, tot 12 duim in diameter, en lê in sagte, groenerige, splinterige skalie. Die fosfaat verweer in 'n kenmerkende blou kleur wat te wyte kan wees aan klein hoeveelhede ysterfosfaat (vivianiet). Die fosfaat van die boonste sone word in harde yster- en mangaanhoudende, sanderige skalie aangetref. Die fosfaatlense verweer nie maklik uit die omhulsels nie. Bruin, veselrige kalksteen kom hier en daar in hierdie sone voor.

Op vars breukvlakke is die fosfaat altyd donkerbruin. Die hoogste P_2O_5-waardes is in die middelste sone teëgekom. Alhoewel die fosfaat uit die skalie en omhulsels verweer en teen die skuinstes af as eluviale afsettings voorkom, is dit op baie plekke met kalsiet- en kwartsare gekontamineer.

Die aard van die fosfaathoudende mineraal is al heelwat bestudeer. Strydom (1950, p. 279–281) wat die voorkoms van fosfaatkonkresies in die Bo-Dwykaskalie in die omgewing van Laingsburg ondersoek het, meld dat volgens petrografiese, chemiese en spektrografiese analises, die fosfaat kollofaan is wat hoofsaaklik uit fluoorhoudende kalsiumfosfaat met 'n

Fig. 5.—Gegewens van boorgate in die Krytsisteem.
Data of bore-holes in the Cretaceous System.

THE GEOLOGY OF THE SWARTBERGE, THE CANGO VALLEY AND THE ENVIRONS OF PRINCE ALBERT, C.P.

SUMMARY IN ENGLISH

by P. J. Rossouw, M.Sc.

INTRODUCTION

This area of 1995 square miles is situated between 21° 30′ and 22° 30′ longitude east and 33° 00′ and 30° 30′ latitude south in the Southern Karroo. The northern half of the area consists of open, relatively flat-lying Karroo country; the southern half is crossed by the Swartberg Range with peaks rising to over 7000 feet above sea-level. The Karroo and the rather densely populated Cango Valley are connected by road over the picturesque Swartberg Pass. A narrow gorge, Meirings Poort, affords another road connection between Beaufort West and Oudtshoorn. The well-known Gamkaskloof lies in the mountainous southwestern part of the area. Before the construction of a road from Kliphuis Vley (B. 2) into this isolated spot, the inhabitants could reach the outside world only by foot-paths and steep mountain trails.

The old water-mill in the outskirts of Prince Albert (Telford, 1958' p. 37–38), in operation since 1870, and the famous Cango Caves, discovered in 1780 and situated in the Cango Valley on the southern slopes of the Swartberge, are national monuments.

Sheep farming is the main occupation in the northern half of the area; but vegetables and fruit are also produced and wheat and lucerne along the larger rivers. More extensive fruit farming is practised in the fertile valleys on the Bokkeveld beds and in the Cango Valley. In the latter locality ostriches were reared for their feathers before the great slump in the feather market in 1914.

Ever since 1871 this area with its multiplicity of formations and its interesting geological structure has received the attention of geologists. Dunn, Atherstone and Bain (1871, p. 2–3) found Devonian shells and Beaufort reptiles. Dunn (1873, p. 12–13) was the first to establish the glacial origin of the Dwyka tillite. Molyneux (1881, p. 8–10) and Green (1883, p. 5) studied the Karroo beds and their structure; the latter, however, differed from Dunn in postulating that the carbonaceous shales of the Upper Dwyka Stage do not contain coal-seams in the Karroo Basin. The rocks of the Cango Valley also received attention from the earlier geologists as well as from Corstorphine, Rogers and Schwarz, and by the turn of the century the more common rock-types such as schist, conglomerate, limestone, grit and diabase were described and correlated with the Malmesbury Formation (Rogers and Schwarz, 1898, p. 61–62). In 1900 Schwarz described in detail the Bokkeveld beds at Gamka Poort, and in 1904 the rocks of the Cape System farther to the east. The prominent thrust on Roosendal (B. 3) was specifically mentioned. Rogers and Schwarz in fontein (A. 1) that rocks of the Ecca Series pass conformably upward into the Lower Beaufort Series. From 1904 to 1909 the origin and nature of the Witteberg quartzite on Groote Tyger Berg (A. 4) was debated by Sandberg and Schwarz. The dispute was finally closed by the clear description by Rogers (1909, p. 135–139) that the Groot Tierberg is built by a normal anticline of Witteberg rocks.

An occurrence of gold on Ganze Kraal (A. 4) was investigated by Dr. Rogers in 1916. Invertebrate fossils in the Bokkeveld beds at Gamka Poort and at Weltevrede (B. 2) were collected and described by Boonstra, Rennie, Gevers and Rossouw between 1928 and 1931. Investigation of the Cango beds in Schoemans Poort by McIntyre in 1932 led him to believe that they were at least of two ages. Younger beds were supposed to rest unconformably on altered schist, granite and gneiss in the southern part of the poort. Mapping by Stocken in 1951 and 1952 failed to substantiate the presence of granite. The Cango Caves were investigated in detail by King in 1952 and mapped by the South African Spelaeological Association in 1956.

The present investigation started in 1939 when Mr. P. J. Rossouw surveyed the northern half of the area to assess the possibilities of finding oil. Mr. E. I. Meyer mapped the Bokkeveld beds from the western boundary to Reime Hoogte in 1947 and 1953. The Cango beds in the southwestern and southeastern parts and around Klaarstroom were investigated by Mr. M. P. Mulder in 1952 and 1953. Mr. C. G. Stocken, a student of the University of Cape Town, mapped the central Cango in 1951 and 1952 under the University Mapping Scheme of the Geological Survey. All mapping was done on aerial photographs and transferred on to base-maps of the Surveyor-General from which the final map was compiled.

PHYSIOGRAPHY

The flat-lying northern half of the area standing at an elevation of some 1300 feet, is directly drained by the Gamka and Dwyka Rivers and their tributaries. A peculiar highveld (3500 feet) in the northeastern corner is drained by eastward-flowing rivers. At about latitude 33° 15′ the open Karroo country with its sparse vegetation terminates against steep ranges of folded Witteberg quartzite rising to elevations of 4218 feet. The mountains of Table Mountain sandstone farther to the south are separated from the Witteberg by a valley underlain by Bokkeveld beds and called " Die Gang " (literally " The Passage ") which is crossed by watersheds the highest of which are Kriedouberg and Bosluiskloof Pass (3600 feet). The Swartberg Range with peaks up to 7060 feet, lie at about 6000 feet above sea-level, and is built of Table Mountain sandstone that is folded from south to north in a syncline and anticline. The latter forms a nose on Middlewater (B. 4). The syncline pitches westward from Swartberg Pass and forms the Gamkaskloof lying at an elevation of some 1050 feet. The Cango south of the Swartberge is a mature, incised plateau standing at more than 2500 feet above sea-level. The hilly portion built by grit and conglomerate stands at 3000 feet and is cut by the southward-flowing Grobbelaars, Wynands and Kruis Rivers. In the extreme southwestern corner of the area the Sandberg (B. 1) reaches an elevation of 2988 feet. The fertile Cango Valley lies at the foot of the Swartberge. On Roodewal (B. 3) there is a fall of the landscape to about 2000 feet along the Cango Fault which let down the Enon beds (Cretaceous) against the older formations.

The climate on the whole is dry with a great difference in day and night temperatures. The summer is hot (up to 37°C); autumn and spring and part of the winter have delightful sunny days. " Bergwinds " blow from the mountains at times. The rainfall varies with the relief. The annual average precipitation at four localities in the northern (Karroo) part of the area amounts to 168 mm and a maximum of 865 mm was measured on the Swartberge. In the Cango Valley the figure drops to 582 mm and as low as 163 mm near Calitzdorp. The northern part is especially subject to droughts and thunder storms. The best rains appear to fall in March, April and May and at times also toward the end of the year.

The greater part of the area is drained by the Dwyka and Gamka Rivers and their tributaries. Only in a few instances is the course of a river influenced by the structure of the rocks over which it flows. Braided rivers and deferred junctions occur. Meanders in various places in the northern part of the area point to a mature landscape in the not too distant geological past. The northern slopes of the Swartberg Range are drained by streams flowing across the Bokkeveld (Die Gang) and Witteberg beds. The latter were incised forming deep defiles. There are many examples of superposition of rivers as for example on Kaffirs Kraal and De Gang (A. 3), the Waterkloof River south of Weltevrede (B. 2), and the lower course of the Gamka before it joins the Dwyka River. Dendritic drainage-patterns are encountered over most of the area, and a trellised pattern in the central Cango. Apart from flowing rivers in the Swartberge, the majority of the rivers in the area flows intermittently. The fall of the larger rivers is accelerated as soon as they enter the sandstone (quartzite) formations of the defiles.

According to the classification of Acocks (1953, p. 85–88, 118–119 and 151–154) the vegetation of the area is composed of the following types: (*a*) Spekboomveld on the Witteberg and Bokkeveld beds and the lower parts of the Cango, dominated by the spekboom (*Portulacaria*), (*b*) Karroid Broken Veld, and (*c*) the Succulent Karroo in the northern half of the area with a very low rainfall, and characterised by succulents like *Crassula*, *Euphorbia*, *Mesembrianthemum*, *Euclea*, etc., (*d*) the Mountain Renosterbosveld in the higher parts of the Cango where *Elytropappus* has supplanted the original grass, and (*e*) the False Macchia of the Cape Flora occupying the highest parts of the Swartberge where the soils are poor and sour. Species of the Restiaceae and Proteaceae are common. Five species of the latter genus are confined to this area.

TABLE OF GEOLOGICAL FORMATIONS

Tertiary to Recent			Alluvium, surface-limestone, talus, terrace-gravel
Cretaceous System	Uitenhage Series	Enon Stage	Conglomerate and sporadic sandstone bands
Karroo System	Beaufort Series	Lower Beaufort Stage	Sandstone, the Poortjie sandstone, purple and blue mudstone, nodules of lime, "chert" and vertebrate fossils of the *Tapinocephalus* Zone
	Ecca Series	Upper Ecca Stage	Sandstone, shale and blue mudstone
		Middle Ecca Stage	Blue shale
		Lower Ecca Stage	Sandstone and blue shale
	Dwyka Series	Upper Dwyka Stage	Grey slate, White Band shale, dark shale with phosphatic nodules and bands of chert
		Lower Dwyka Stage	Tillite
Cape System	Witteberg Series		Blue shale, white and grey quartzite and purple, micaceous shale
	Bokkeveld Series		Four sandstone bands alternating with five shale bands, passage beds at the bottom, and invertebrate fossils
	Table Mountain Series		Grey, quartzitic sandstone, one shale band with tillite at its base, basal conglomerate in places
Klipheuvel Formation			Light grey sandstone
Cango Formation	Holgat Series(?)	Upper Greywacke Zone	Rhythmically bedded greywacke and shale or argillaceous siltstone
		Cross-bedded Grit Zone	Basal conglomerate with monomictic and polymictic varieties, passing upward into cross-bedded grit, quartzite and arenaceous shale
		Lower Greywacke Zone	Greywacke containing lenses of grit, limestone, shale and quartzite
	Hilda Series (?)	Limestone Zone	Limestone, shale, subsidiary lenses of arkosic grit and sandstone

Intrusive rocks

Pos -Cango (Precambrian)	Diabase

THE CANGO FORMATION

The Cango Formation (Proterozoic) is made up of a thick succession of grit, conglomerate and greywacke with subordinate bands of limestone, shale, sandstone (quartzite) and arkose. The whole formation is extensively overfolded, faulted and sheared and forms the core of a large anticline of Table Mountain Series the northern limb of which is overfolded and dips southward underneath the Cango rocks. The southern limb is cut off by the Cango Fault bringing the Cango beds to lie adjacent to the Uitenhage Series, with strips of Table Mountain Series and Klipheuvel beds lying between the former two formations. The Cango Formation consists of the following zones, from the bottom upwards:—

The Limestone Zone forms the fertile Cango Valley from Kruis River (B. 2) to Rust en Vriede (B. 4). In the north-central part of the valley the Table Mountain Series overlies this zone unconformably whereas along the southern contact a thrust brings the zone to lie against the younger Cross-bedded Grit Zone.

Lithologically the zone consists of bands of limestone and shale containing lenses of arkosic grit and sandstone. The Cango Caves lie in a limestone band whose thickness exceeds 4000 feet. The limestone is a blue-black rock with numerous veins of quartz, chert and calcite. According to Wybergh (1920, p. 60–61) the limestone is a pure calcite variety of good quality. Microscopically it has a clastic texture, being composed of limestone fragments (often rounded), oolites, quartz and calcite in a fine-grained matrix of calcite and carbonaceous material. The shale and slate are highly sheared, brittle and greenish or reddish in colour. The arkosic grit occurs as isolated, darkish, coarse-grained lenses that contain bands of conglomerate. The pebbles of the latter are of gneiss, granite, dolomitic limestone and chert, and are set in a quartzitic calcareous matrix. The grit varies from quartzitic to arkosic depending on the presence of quartz, quartzite and reddish feldspar (chiefly microcline and orthoclase). The sandstone contains rounded quartz grains and about 7 per cent feldspar. These beds dip steeply to the south and are very probably overfolded.

The Lower Greywacke Zone is composed of a highly folded succession of fine-grained, dark blue-grey, massive greywacke passing laterally in the west into shale and subgreywacke with lenses of limestone, quartzite and grit. Near the western and eastern boundaries of the sheet the limestone lenses are missing. The average greywacke (subgreywacke) consists of about 55 per cent detrital quartz, 40 per cent chlorite-sericite matrix, 2 per cent feldspar (orthoclase, microcline, little plagioclase) and not more than 4 per cent carbonate fragments; the heavy-mineral fraction contains magnetite, zircon, epidote, tourmaline, pyroxene and rutile. The grit is predominantly quartzose and is composed of angular quartz grains in a matrix of finely crushed and recrystallised quartz, chlorite, sericite and iron ore. The scattered limestone lenses are grey, very hard, fine-grained, and composed of calcite and scattered quartz grains.

The Cross-bedded Grit Zone builds the barren upland of the central Cango which is about 4 miles wide. A thickness of about 6000 feet seems indicated. The basal conglomerate was recognised as such by Corstorphine in 1897 and called the " Cango Conglomerate " by Rogers and Schwarz in 1900 (p. 68). It consists of monomictic and polymictic conglomerates. The former type is made up of well-rounded, spherical pebbles of vein-quartz (up to 3 or 4 inches in length) and flattened fragments of banded ironstone in a massive, arenaceous matrix. The conglomerate is graded and passes upward into grit that is devoid of pebbles. In the central Cango the thickness of this band is about 3000 feet and it appears to be fluviatile in origin, having been transported over great distances. The massive monomictic conglomerate is replaced locally by polymictic conglomerate of varying thickness and made up of débris of the nearby underlying lower greywacke set in an argillaceous matrix. Although pebbles of quartz are present the majority is of blue greywacke and angular shale and phyllite. The pebbles are unsorted and not bedded. Unlike the massive and competent matrix of the monomictic conglomerate, that of the polymictic conglomerate is greenish, argillaceous, sheared and compressed into fine laminae enfolding the pebbles. The fragments of shale are drawn out into ribbons or crushed along with the matrix into flat glistening patches. The long axes of the pebbles are invariably parallel to the dip of the cleavage-planes. The polymictic conglomerate lies more often than not at the base of the zone. In places contorted shale with scattered quartz pebbles and phyllitic and serisitised quartzite are found at the base. These rock-types grade into conglomerate and sheared grit.

The cross-bedded grit is blue grey in colour, poorly sorted, and contains grains and pebbles of white vein-quartz. The tabular cross-bedding (McKee and Weir, 1953, p. 384), and foreset beds, 10 feet long and dipping at 15°, tend to prove that deposition took place by means of quick-flowing fluviatile streams. Microscopically the grit consists of about 85 per cent angular quartz grains, 10 to 15 per cent sericite-chlorite matrix, less than 5 per cent feldspar and some 2 per cent carbonate flakes. The heavy-mineral fraction includes magnetite, zircon, apatite, epidote, tourmaline and orthopyroxene. In the western part of the Cango the rock, by admixture with argillaceous material, is more of an argillaceous quartzite (greywacke) with only 30 per cent quartz grains and 50 per cent fine-grained, sericite matrix.

A mottled feldspathic grit is encountered in the upper part of the zone just west of the 22° line of longitude. Reddish alkali feldspar forms some 20 per cent of the rock, quartz and small granite fragments account for 74 per cent; the rest is matrix.

The Upper Greywacke Zone. The underlying cross-bedded grit grades into the greywacke of this zone which is constituted of a rhythmic alternation of greywacke and shale or argillaceous siltstone. Whereas the bands of greywacke at the base of the succession are up to 3 feet thick, alternations of only 1-inch bands are encountered higher up in the zone. Deposition seems to have taken place through seasonal flooding of a mature stream of waning competency.

The beds have suffered considerable shearing and consist of a mosaic of about 60 per cent crushed and recrystallised quartz and 35 per cent interstitial chlorite with some feldspar and carbonate fragments. Heavy minerals are much the same as in the cross-bedded grit.

The deposition of the Cango beds seems to have taken place under miogeosynclinal conditions so that great thicknesses of grit and greywacke without interbedded chert or " greenstones " were deposited. From the composition of the greywackes it seems probable that tectonic conditions in the source area were of an epeirogenic nature. The great thickness of coarse grit and conglomerate is suggestive of tectonic instability in the source area involving rejuvenation of relief and resulting in an abundant supply of coarse detritus being delivered to the depositional site. The almost constant nature of the heavy-mineral content, and the presence of iron ore and well-rounded zircon grains suggest prolonged erosion of a uniform sedimentary rock series over a wide area. The presence of some granite and basic igneous rocks in the source area is suggested by zircon, tourmaline, diopside, feldspar, augite and enstatite grains in the Cango sediments. The deposition of the rhythmically banded greywacke at the top of the succession points to a gradual return to epeirogenic conditions in the source area. The banded structure indicates that the competency of the streams was so reduced that only during times of flood could they deliver sand to the depositional site.

The Cango beds are similar, both lithologically and stratigraphically, to the Pre-Cape rocks of the Gamtoos Valley described by Amm (1935, p. 69–86), Frankel (1937, p. 273–289), and Haughton and Visser (1937, p. 14–21). Although the succession of the Pre-Cape rocks near George as described by Potgieter (1950, p. 323–412) differs appreciably from that of the Cango beds, the petrology and structure show certain resemblances. According to Truter (1950, p. 29–89) part of the Cango succession is similar to the Malmesbury Formation. De Villiers (De Villiers et al., 1964) considers that the Malmesbury Formation may be correlated tentatively with the Gariep System. The Limestone Zone of the Cango is thus tentatively correlated with the Hilda Series of the Gariep System and the Greywacke and Cross-bedded Grit Zones with the Holgat Series of the same system.

THE KLIPHEUVEL FORMATION

Rocks considered to be equivalent to the Klipheuvel Formation (Proterozoic?) are represented by a narrow strip of feldspathic grit on Roodewal (B. 3) and environs where they dip underneath the Table Mountain Series and rest with a faulted contact on the Upper Greywacke Zone of the Cango Formation. The basal conglomerate resembles the polymictic conglomerate of the Cango and apparently received its constituents from the débris of this conglomerate. A few irregular shale bands are encountered higher up in the succession. The grit is composed of 70 per cent angular quartz grains and 13 per cent feldspar in a fine-grained sericitic matrix. The heavy-mineral fraction is made up of magnetite, zircon, tourmaline, apatite, epidote and orthopyroxene.

THE CAPE SYSTEM

The Table Mountain Series (Upper Silurian–Lower Devonian) which is made up chiefly of quartzitic sandstone, forms the Swartberge and the mountainous portion of the Huisrivier Pass in the southwestern corner near Opzoek (B. 1). Although the series overlies the Cango Formation unconformably, both are overfolded to the north. The sandstone is a hard, white to grey, even-grained, quartzitic rock, cross-bedded in parts, and composed of quartz grains of uniform size, scattered feldspar grains and irregular white vein-quartz pebbles. A basal polymictic conglomerate, some 450 feet thick, was encountered from the western margin of the area as far as 22° longitude east, and contains pebbles of dark chert, quartz and quartzite in a gritty matrix. Where the quartzitic sandstone is highly disturbed and fissured it is coloured reddish by oxidised iron compounds. As a result of bedding-planes and numerous joints it is a good aquifer capable of storing copious supplies of fresh water. It gives rise to poor, sandy soils. A thickness of about 10,000 feet has been measured near Prince Albert.

According to Rogers (1904, p. 280; 1925, p. 9–11), Du Toit (1954, p. 575) and King (1951, p. 310) Gamka Poort is an incised meander that originated on Enon beds. Opposed to this are the views of Davis (1906, p. 613), Taljaard (1948, p. 13; 1948a, p. 118), Maske (1957, p. 16) and Lenz (1957, p. 205) that the poort was formed by a stream cutting back from the escarpment caused by the Cango Fault. This process was facilitated by open joints in the folded beds.

Drainage by the Gamka River and its tributaries did not proceed at an even rate as is evidenced by benches of erosion and terraces that are remnants of earlier land-surfaces.

The erosion-level at 3000 feet along the southern slopes of the Swartberge is dated as Miocene–Pliocene. The high-level terraces of Prince Albert are considered by Lenz (1957, p. 223 and 227) to be of this age. Other land-surfaces are the watersheds Kriedouberg and Bosluiskloof, both at 3500 feet above sea-level, and the highveld (3500 feet) in the northeastern corner of the area. Rivers draining the southern edges of the latter feature are incised meanders in sandstones of the Lower Ecca Stage. Other surfaces are evidenced by terraces on Vrisgewaagd (A. 2) at 2660 feet, and along the Gamka in Gamka Poort at heights ranging from 1250 to 3040 feet. There are also numerous terraces along the Gamka and Dwyka Rivers, their tributaries and rivers flowing eastward out of Die Gang (B. 4), lying at heights varying from 20 to 600 feet.

THE CANGO CAVES

The Cango Caves are situated on an east–west zone of faulting in a limestone band of the Cango Formation on the farm Kombuys (B. 3). They remain at more or less a constant height and follow a twisting course; one can walk for about 2 miles underground (see figs. 1 and 2). The biggest chamber is about 300 feet long and 60 feet high. The caves are beautifully ornamented with stalagmites, stalagtites and helictites (see pls. I and II). They are dry with a temperature of 18·3°C and filled by fresh air. It seems that the caves were formed by solution of the limestone by phreatic water during the Middle Tertiary when the water-table stood much higher under an old land-surface. Remnants of this surface are present along the base of the Swartberge in the vicinity of the caves. After the caves had been drained the deposition of dripstone began. Red clay is present in the caves but no aeolian sand of the Kalahari type (King, 1958, p. 45–54). According to Walker (1957, p. 11) and Macpherson (1958, p. 45–48) there are more caves in the vicinity in the Cango Valley, one of them, the Emerald Lake Cavern, being filled by water.

UNDERGROUND WATER

The part of the area north of the Witberge has a low rainfall and is dependent for its water-supply on bore-holes and wells. The underground water occurs in joints, fissures and fault-zones in the rocks and also in unconsolidated alluvial deposits. Springs of the barrier or contact type are found here and there.

A fair percentage of the rainfall infiltrates as the soil cover is thin and the joints and bedding-planes provide easy ingress. Nevertheless as a result of increasing demands, more and more bore-holes have been drilled and in many places the water-table has been appreciably lowered.

Graphic presentations showing bore-hole data in the various geological formations are depicted on folder 1 and text-figures 3 to 5.

From available records it appears that about 50 per cent of the bore-holes in the Cango Formation are either failures or yield less than 100 g.p.h. The beds are in general poor aquifers because they are for the most part fine-grained, compact and impermeable. In many instances the water is brack. Fair yields, however, may be expected in the Limestone Zone when fissures or cavities are encountered in bore-holes. The alternation of shaly and sandy bands in the Lower Greywacke Zone favours the occurrence of water. The Cross-bedded Grit Zone ought to contain water because of its coarse, sandy nature, but, as it forms hilly and sparsely populated country, it has not been extensively drilled.

The quartzitic, mountain-building Table Mountain Series receives a generous supply of rain-water, and as it is extensively fissured, it is one of the best aquifers in the country. Springs are frequently encountered in the mountain ranges and yield fresh water to the neighbouring farms and towns by way of rivers that drain the higher lying ground. Fresh water is encountered in the three sandstone and intervening shale bands in the lower Bokkeveld Series. The upper shales, however, yield brackish water. From text-figure 4 it is apparent that most of the water is encountered at depths varying between 20 and 100 feet. Bore-holes in and near the quartzite bands of the Witteberg are generally successful in striking water which may be fresh or brackish. In the shaly uppermost Witteberg (formerly Lower Dwyka shales) the water tends to be sulphuretted.

As the Dwyka tillite is not bedded, underground water is found in joints and fissures. Apart from these the tillite is very hard to drill. Brackish (in places sulphuretted) water is found in more than 50 per cent of the bore-holes. In the others the water is slightly brackish or sulphuretted. The shaly Middle Ecca Stage yields more often than not a constant supply of fresh water. The arenaceous Upper Ecca Stage and Lower Beaufort Stage are constituted by an alternation of shale and sandstone bands, and yield only very slightly brackish water that is fit for human consumption—supplies of up to 4000 g.p.h. have been struck.

The Enon conglomerate of the Cretaceous System is virtually impermeable due to its clayey matrix. About 65 per cent of the bore-holes are failures. The sandstone bands in this formation south of the area are, however, good aquifers. Although the water is generally brackish, it is potable.

Underground water has been encountered in wells sunk in the unconsolidated débris along some of the rivers in the area, e.g. along the Grobbelaars River on Roodewal (B. 3). The gravel-filled courses of rivers flowing northward out of the Cape Folded Belt at Prince Albert and on Weltevrede (B. 2) contain copious supplies of water even after the rivers have ceased flowing.

ECONOMIC GEOLOGY

Building material is obtained from the bedded quartzite, slate, chert and sandstone of the Witteberg, Upper Dwyka and Lower Ecca beds. Crushed Witteberg quartzite yields aggregate for building purposes and road-metal.