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Department of Industries  
BOMBAY PRESIDENCY

**Notes on the Indian Textile  
Industry with Special  
Reference to Hand  
Weaving**

By

**R. D. BELL, C.I.E., I.C.S.**

**Bulletin No. 6**

[Price—Annas 11 or 1s. 2d.]

BOMBAY

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1926

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At a time when the discussion on the abolition or otherwise of the Cotton Excise Duty was going on rather furiously in the press and on the public platform, my predecessor, Mr. R. D. Bell, C.I.E., I.C.S., compiled a very useful series of tables with explanatory notes from various sources available in the Department of Industries to show what part the handloom industry still performed in the industrial activities of this country.

2. A few typed copies of these notes were sent out to those interested in the question, and, as the notes are still in demand by students of Indian economics and others, I have had them printed and published in the form of a departmental bulletin, as I believe these notes will serve as an eye-opener for those who often preach without study or investigation that handloom weaving is a dying cottage industry or that it has been killed by the competition of the cotton mill industry established in this country.

3. The competition of cotton mills with hand-weaving in this Presidency started nearly three-quarters of a century ago when the late Mr. Cowasjee Nanabhai Davar established the first cotton mill in Bombay in the year 1853. Since then in spite of the advantages of mass production of the well organised mill industry the handloom weaving industry has not declined for various reasons.

4. In the first place the handloom industry has been greatly profitted and stimulated by the sufficient supply of mill-spun yarns of regular counts and twists in place of the rough and knotty hand-spun yarns of uncertain counts. A large portion of the rural population or village dwellers which constitute about 90 per cent of the total population of this country still prefer the coarse but durable hand-made product, and there are still many specialised types of hand-made cloth used by the urban population in this country which cannot be economically produced on power looms. Only those hand-weavers who did not specialise in any kind of fine fabrics but wove only coarse and plain cloth like khadi or dungri have

found it very hard to face mill competition and have taken to working for wages in mills or elsewhere. Even in khadi the competition of the mills is very little, as in the villages it is produced from inferior cotton which cannot stand the rough treatment of mill machinery.

5. A handloom worker, being more intimately acquainted with the tastes and requirements of his customers than a weaving master of a cotton mill, can easily satisfy the demand of a rural area. The mill-made cloth has not yet penetrated in certain rural areas where the cost of transport is very great owing to the absence of railways, and the hand-woven cloth therefore continues to be in good demand in such places.

6. Beautiful solid bordered saris and dhoties and artistic cross bordered raiment of numerous patterns and variegated designs which cannot be produced economically on power looms are invariably produced on handlooms. In solid bordered hand-woven fabrics two different kinds and colours of weft are used for the body and for the borders. As for instance the body of a cloth may be white and its borders red, but the white weft passes through the body only without passing through the borders, while the red weft passes through the borders and not through the body. In this way if the warp used for the borders is also red then borders of beautiful and brilliant red are produced which are called "solid borders" in textile technology. This can be produced in a special kind of power loom called pick-and-pick loom but not without a great deal of wastage and difficulties.

7. Similarly sari headings are also woven in handlooms with so-called broken weft which is not possible to work economically in power looms. In such fabrics the weft does not pass through the whole width of the cloth but it passes through a certain width of the cloth and then a weft of another colour is inserted to give a peculiar effect. This kind of changing of weft at different places at every pick produces an unique design which it is not possible to produce automatically in a power loom.

8. The warp of a handloom weaver being only thirty to forty yards in length he can easily introduce new designs and new patterns in each piece of cloth of that length at the time of preparing the warp. This is not possible in a large cotton mill as the warp of a power loom is not only about as much as eight hundred yards long but a large number of such warp beams of only one pattern have necessarily to be prepared to cope with the mass production system with the result that a mill-owner cannot accept an order for a certain style of cloth unless it is of several thousand yards of one pattern.

9. The sphere of the hand-weaver therefore still remains unsurpassed and unsurped to a large extent by the mill competition in this country.

BOMBAY,  
*15th July 1926.*

F. E. BHARUCHA,  
Director of Industries.

## PREFACE

In the course of a debate on the Cotton Excise Duty in the Imperial Legislative Assembly on 20th March 1924, I quoted statistics to show the great importance, even now-a-days, of the Indian hand-weaving industry. The facts were so little known that they caused surprise and I received requests from several quarters for the complete statistics.

I have brought out the important features of the statistics in these notes. These were the basis of a lecture, entitled "Hand Weaving and Allied Crafts," which I gave to the Bombay European Textile Association in March 1923. The "Allied Crafts," viz., carpet-weaving, silver and gold thread manufacture, calico printing and dyeing, have been omitted from the present notes.

The statistics are by no means novel. The Indian Industrial Commission in Appendix I to its report gave statistical evidence regarding the development of hand-weaving in India. The importance of the industry is also explained in "Notes on Indian Piece Goods Trade" by A. C. Coubrough, C.B.E., which was published by the Government of India as No. 16 of their Bulletins of Indian Industries and Labour.

All the statistics are extracted from the following official publications :—

1. Monthly statistics of cotton spinning and weaving in Indian mills.
2. Annual statement of the Sea-Borne Trade of British India.
3. Accounts relating to the trade by land of British India with foreign countries.

The notes which were first compiled in 1924 have now been brought up to date. I am indebted to Mr. S. Y. Anandkar, Head Clerk of the Director of Industries, for revising the tables and to the Director, Mr. F. E. Bharucha, for arranging to publish the notes and tables.

BOMBAY,

R. D. BELL.

21st April 1926.

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## APPENDIX No. I.

*Oil contents of the principal Indian oil seeds available in the  
Bombay Presidency.*

Name.	Botanical name.	Oil content per cent.
Castor seed ..	Ricinus Communis ..	46·50
Copra ..	Cocos Nucifera ..	65·70
Cotton seed ..	Gossypium Herbaceum ..	16·19
Groundnuts ..	Arachis Hypogaea ..	44·50
Jamba seed ..	Eruca Sativa ..	32·35
Linseed ..	Linum Usitatissimum ..	42·44
Mustard ..	Sinapis Nigra ..	31·33
Mowrah ..	Bassia Latifolia ..	40·45
Niger seed ..	Guizotia Abyssinica ..	35·37
Poppy seed ..	Papaver Somniferum ..	45·50
Rape seed ..	Brassica Campestris ..	40·45
Safflower seed ..	Carthamus Indicus ..	30·32
Sesamum seed ..	Sesamum Indicum ..	45·55



APPENDIX No. II.

*Principal Manufacturers of Oil Mill Machinery and Plant for the treatment of Vegetable Oils.*

Names.	Addresses.	Local Agents.
UNITED KINGDOM.		
1. Messrs. A. F. Craig & Co., Ltd. ..	Paisley, Scotland.	
2. „ Greenwood & Batley, Ltd. ..	Leeds .. ..	Messrs. Duncan Stratton & Co., Bombay.
3. „ Robert Middleton & Co., Ltd.	Sheepscar, Leeds .. ..	Messrs. Macbeth Bros. & Co., Ltd., Bombay.
4. „ Manlove Elliott & Co., Ltd.	Nottingham .. ..	Messrs. J. Fleming & Co., Bastion Rd., Bombay.
5. „ Rose, Downs & Thompson, Ltd.	Hull (Hydraulic Pressing and Sol- vent Extraction Plant).	Messrs. Marshall Sons & Co., Ltd., Ballard Road, Bombay.
6. „ George Scott & Co., Ltd. ..	Kingsway Home, Kingsway, Lon- don W. C. (Solvent Extraction Plant).	
7. „ Scott & Sons, Ltd. ..	72, Oxford St. London, W. 1. (Sol- vent Extraction Plant).	
8. Mr. Howard Lane .. ..	Ashford, Middlesex. (Hydrogena- tion Plant).	
9. Messrs. Blair, Campbell & McLean, Ltd.	Govan, Glasgow (Hydrogenation Plant).	
10. Messrs. L. H. Johnson & Co., Ltd. ..	Carpenter Road, (Filter Presses) Stratford, London, E.	

*United States of America.*

- |   |   |  |
|---|---|--|
| 1. Messrs. The American Machine and Manufacturing Co. | Greenville S. C. (Oil Mill Machinery).                        |  |
| 2. Messrs. Barnard & Leas Mfg. Co. ..                 | Moline Ill : (Cotton seed Hull Packing Machinery).            |  |
| 3. Messrs. Baner Bros. .. ..                          | Springfield, Ohio. (Cotton seed Decorticating Machinery).     |  |
| 4. Messrs. Brecht Co. .. ..                           | St. Louis, Missouri (Oil Refining Plant).                     |  |
| 5. Messrs. Buckeye Manufg. Co. ..                     | Dayton, Ohio (Oil Mill Machinery).                            |  |
| 6. Messrs. The Buruss Engineering Co.                 | Atlanta, Georgia (Anderson Oil Expeller).                     | Y. G. Pandit, Bombay.                          |
| 7. Messrs. Cardwell Machinery Co. ..                  | Richmond Va. (Oil Mill Machinery).                            | Messrs. J. Fleming & Co., Bastion Rd., Bombay. |
| 8. Messrs. The Diamond Huller Co. ..                  | Winona, Minn. (Cotton seed Decor-ticators).                   |  |
| 9. Messrs. The French Oil Mill Machinery Co.          | Piqua, Ohio (Oil Mill Machinery).                             |  |
| 10. Messrs. The Murray Company ..                     | Atlanta, Georgia (Cotton seed Oil Mill Machinery).            |  |
| 11. Messrs. Sprout Waldron & Co. ..                   | Muncy, Pen. (Cotton seed Decorticating & Grinding Machinery). |  |

*Holland.*

- |                           |   |   |
|---------------------------|---|---|
| Messrs. Frans Smulders .. | Utrecht, Holland. (Expellers & Oil Mill Machinery). | The Holland Bombay Trading Co., Ltd., Bombay. |
|---------------------------|---|---|

APPENDIX No. III,

*List of useful Books on the Manufacture and Treatment of Vegetable Oils.*

Author.	Title.	Publisher.
1. Andes, Louis E.	"Vegetable Fats and Oils "	Scott Greenwood & Co.
2. Do.	"Drying Oils, Boiled Oil and Solid and Liquid Driers."	Do.
3. Archbutt & Deeley	"Lubrication & Lubricants "	C. Griffen & Co.
4. Brodie, N.	"The Manufacture of Paint and Varnish in India."	The Superintendent, Government Printing, Calcutta, for Indian Munitions Board.
5. Chalmers, T. W.	"Production & Treatment of Vegetable Oils."	Constable & Co.
6. Ellis, Carlton B.	"Hydrogenation of Oils "	D. Van Nostrand, New York.
7. Ennis, William D.	"Linseed oil and other seed oils "	Do.
8. Fryer & Weston	"Oils Fats and Waxes "	Cambridge University Press.
9. Holde & Mueller	"Examination of Hydrocarbon Oils."	John Urby & Son, New York.
10. Hurst, Geo H.	"Lubricating Oils, Fats & Greases "	Scott Greenwood & Co.
11. Do.	"Soaps "	Do.
12.	"Industrial Handbook 1919 "	Indian Munitions Board.
13.	"International Library of Technology Sections 36 to 44 "	I. C. Schools.
14.	"Oilseeds and Feeding Cakes "	Imperial Institute, London.
15.	"Oilseeds, Oils, Fats & Waxes "	Do.
15A.	Colonial Reports (Miscellaneous).	Do.

16.			"Quarterly Reports of Imperial Institute."	Do.
17.			"Oil content of some South Indian Oilcakes." Journal of Indian Institute of Science, Vol. 1, Part XIX.	Mysore Residency Press.
18.			"Oil Splitting by Castor Seed Lipase." Journal of Indian Institute of Science, Vol. 2, Part XV.	Do.
19.	Koppe, S. W.	..	"Glycerine"	Scott Greenwood & Co.
20.	Lamborn, L. L.	..	"Cottonseed Products"	Do.
21.	Do.	..	"Soaps"	Do.
22.	Lewkowitch, D. J.	..	"Chemical Technology & Analysis of Oils, Fats and Waxes." 3 Vols.	MacMillan & Co.
23.	Noel Paton, F.	..	"Indian Cottonseed ; Its Industrial Possibilities."	Superintendent, Government Printing, Calcutta.
24.	Pandit, Y. G.	..	"Report on Oil Pressing Industry of Bombay Presidency."	Bombay Government Central Press.
25.	Simmons, W. H. and Mitchell, C. A.	..	"Edible Fats & Oils"	Scott Greenwood & Co.
26.	Watt, Sir George	..	"The Commercial Products of India."	John Murray.
27.	Wright, C. R. Alder	..	"Animal and Vegetable Fixed Oils, Fats and Waxes."	
28.			"Minute of Evidence of the Committee on Edible Oil Producing Nuts & Seeds of West Africa."	H. M. Stationery Office, London.

## APPENDIX No. IV.

*Average oil content of some English oil-cakes as given by Professor Crowther, M.A., Ph.D., Director of the Institute for Research in Animal Nutrition in the University of Leeds, in a memorandum submitted to the Committee on Edible and Oil Producing Nuts and Seeds (1916).*

No.	Variety.	How prepared.	Average oil content.
1	Palm kernel cake ..	Hydraulic Press ..	6 per cent.
2	Coconut cake ..	Do. ..	10 ..
3	Groundnut cake ..	Do. ..	10 - ..
4	Linseed cake ..	Do. ..	10 ..
5	Decorticated cotton seed cake.	Do. ..	9 ..
6	Undecorticated cotton seed cake.	Do. ..	5.5 ..

## APPENDIX No. V.

*Average oil contents of some American oil-cakes as given by Henry and Morrison in  
" Feeds and Feeding " (1917 Edition).*

No.	Variety.	How prepared.	Average oil content.	Number of samples analysed.
1	Cotton seed cake and meal choice ..	Hydraulic Press, decorticated ..	9.1 per cent. ..	2,556
2	Do. prime ..	Do. do. ..	8.3 " ..	1,322
3	Do. good ..	Do. do. ..	8.2 " ..	482
4	Do. ..	Expeller, undecorticated ..	7.7 " ..	64
5	Linseed cake and meal ..	Hydraulic Press ..	7.5 " ..	714
6	Linseed meal ..	Extracted ..	2.9 " ..	182
7	Groundnut cake ..	Hydraulic Press, decorticated ..	8.0 " ..	2,480
8	Do. ..	Do. undecorticated ..	11.1 " ..	7
9	Coconut cake and meal ..	Hydraulic Press ..	11.3 " ..	11
10	Palmnut cake ..	Do. ..	9.5 " ..	600
11	Rape seed cake ..	Do. ..	9.6 " ..	500
12	Sesamum or tilcake ..	Do. ..	14.00 " ..	150

## APPENDIX VI.

*Extraction of Oils by Solvents.*

FROM THE OIL AND COLOUR TRADES JOURNAL OF MARCH 19, 1921.

The second lecture by Mr. R. A. Bellwood (of Rose, Downs & Thompson, Ltd.), on "The Extraction of Oils by Volatile Solvents" was delivered at the College of Technology, Manchester, on March 10. An interesting and extremely valuable feature of the lecture was the section devoted to the design and construction of oil extraction works utilising the process which was the subject of Mr. Bellwood's remarks.

The lecturer stated that, though a great deal of progress had been made in recent years, there still existed in this country a prejudice against solvent extraction plants when edible oils were required. Provided that the process were properly carried out, it had been proved, however, that oils produced by solvent extraction were quite suitable for edible purposes. Moreover, many chemists were of opinion that extracted oils were much easier to refine than ordinary expressed oil. One argument that had been used against extraction was that a solvent extracted oil contained more free fatty acids than an expressed oil, but such was not the case. The use of a solvent did not increase the fatty acid content, and if more fatty acids were found in a solvent extracted oil it was simply due to the fact that the raw material had not been of equal quality to begin with. Another objection that was sometimes met with was the great risk run in using an inflammable solvent, such as petroleum spirit. Provided, however, that a plant was properly constructed and properly worked, very little danger existed. Notwithstanding this prejudice, there had been great developments in the process. Large plants were now at work, in Hull, Liverpool, Warrington, London, Port Sunlight, and Manchester, the aggregate capacity being between 7,000 and 8,000 tons of oleaginous seeds weekly. Manufacturers were beginning to realise the fact that with the solvent process practically the whole of the oil could be extracted. At the present time, the only drawback was the high price of the solvent. That, however, was bound to be reduced, which would give the solvent

extraction plants a better opportunity of coming to the front. The seeds and oils that could be treated in a properly designed extraction plant were so numerous that there was a very wide scope indeed for the enterprising manufacturer in the future.

To those about to enter the extraction business, the first thing to consider was a suitable site for the necessary buildings. An ideal position was one where both water and railway accommodation could be made available. When choosing a site, it should be borne in mind that there should be room for expansion purposes. Where water accommodation was available, the seed could be brought up in barges and delivered to silos by elevators. In designing a new plant, special attention should be paid to the handling and transporting of the raw materials and the finished products. As regards the buildings themselves, the lecturer recommended these to be of fireproof construction throughout, the silos being preferably of concrete. The ventilation of an extraction house was a very important problem, and should be studied very carefully. Whatever solvent was used, whether inflammable or non-inflammable, ample provision should be made for taking away any vapour caused by leaky joints, or any other cause. Some solvent vapours, though non-inflammable, were detrimental to health, some which were inflammable were only slightly detrimental, while others were both inflammable and injurious. Although the vapours of most of the solvents used in extraction works were heavier than air, and tended to sink to the floor, much of the vapour was carried away if the top of the extraction house was provided with a ventilator louvre running the whole length of the building. It was necessary, however, to have a series of ventilators at the floor level, which would take away any vapours that could not get away otherwise. Extraction houses should be, and usually were, of lofty construction, with top louvres as described. In buildings so constructed it was usually difficult to trace any smell of the solvent being used.

Solvent extraction plants should be well lighted, so that defects might be easily seen and quickly remedied. All the main cables should be carried in steel tubes on the walls outside the building. Wherever possible, all lamps should be of the air-tight bulkhead type,



with water seal, these being let into the walls of the building and connected to the mains outside the building by short branch pipes. As a rule, a plentiful supply of light could be obtained by that method. Where this was not possible, similar lamps might be arranged on the ceiling, all the cables being enclosed in steel tubes. All repair work on the extraction pots should be carried out by the aid of an ordinary battery lamp of good construction.

To obtain the most economical results from an extraction plant, it was essential, said the lecturer, that the type of motor to be installed should have very careful consideration. If the solvent used was an inflammable one, the motors should be arranged outside the extraction house in a vapour-tight building. Most manufacturers preferred an ordinary steam-engine, and took part of the exhaust steam to the extraction house to be used in the solvent evaporators for vapourising the solvent from the oil. Whatever type of driving power was selected, it was necessary to have a boiler for steam production, the steam being essential for distilling off the solvent used from both the oil and the meal. In some plants steam was required for special heaters which drove off a certain percentage of moisture from the raw material before it went to the extraction plant. Steam might also be required for operating drying machines, and also for treating the oil or grease residues. It was usually the practice in designing extraction plants to provide a boiler with a steaming capacity above the actual average steam consumption of the plant. That was a wise precaution, because if anything went wrong, the proper working cycle of the plant was disarranged, with the natural consequence that an abnormal quantity of steam was required at some given period, so as to bring the working back to its proper cycle without loss of time. It might be, when first starting work on a new material, that the estimated time required for extraction might not work out according to calculation, or temporary stoppages might be caused through iron getting into some part of the grinding plant. Even with the most carefully designed plants, and with the best magnetic separators that might happen. To get the best results from a plant, a small recording meter should be fixed to each separate unit, so that it might be definitely ascertained when and where the steam was being consumed.

It was impossible to lay too much stress on a proper preliminary treatment of the material before extraction. All oleaginous seeds or nuts contained greater or lesser quantities of foreign matter, such as stones, iron, sand, and seeds other than those it was intended to treat. If the seeds were not properly cleaned, an inferior oil was obtained, and in some cases the process was retarded, and a smaller percentage of oil obtained on account of the absorbent qualities of the impurities. The theory of extraction was that if ground oleaginous seed was taken and saturated with a solvent, the oil diffused into the solvent, and penetrated into the cells, so that there was a concentrated mixture both in and out of the cells. If, therefore, the quantity of oil in the material being treated was previously known, the amount of the solvent measured, and the amount of mixture run off from the extraction vessel measured, the amount of oil remaining in the material could easily be calculated, as could also the amount of solvent required to bring the oil down to any desired percentage. Briefly explained, the extraction process consisted in : (1) the preparation of the material so that the solvent would pass easily into it, and into the oil cells ; (2) to allow cold or hot liquid solvent or hot vapour to percolate through the material which was contained in an enclosed pan ; (3) to drain off the mixture of oil and solvent from the material into a still ; (4) to drive off the solvent from the oil by heat, as a vapour, and pass through a condenser to liquify and recover the solvent for further use ; (5) to drive off the solvent from the meal by heat, as a vapour, and pass through a condenser to recover as a liquid for future use.

Discussing at some length the ideal solvent material, Mr. Bellwood said the conditions laid down were very exacting indeed : (1) it should neither be inflammable nor expensive ; (2) it should vapourise with the use of only a small amount of heat ; (3) it should dissolve only the oil content of the material under treatment ; (4) it should be of a very searching nature ; (5) it should be a uniform chemical body that would not disintegrate when being distilled off ; (6) it should not give off noxious vapours that would be detrimental to the health of the worker ; (7) it should not cause any chemical change in the material under treatment ; (8) it must not cause deterioration in the

apparatus ; (9) the cost must be low. Needless to say, there was no solvent known that fulfilled all these conditions. Of the many different kinds of solvent materials, only trichloroethylene and carbon tetrachloride could be regarded as safe from explosion and fire. Leaving out the question of specific gravity, carbon tetrachloride was the most favourable as regards the consumption of heat units, both its specific heat and vapourising heat being the lowest. Owing, however, to its higher cost and detrimental effect upon the worker it had been superseded by benzine. The weight of benzine used as against other solvents was as follows :—Compared with carbon tetrachloride 45·9 per cent. ; compared with trichloroethylene, 50·0 per cent. ; compared with carbon bisulphide, 57·2 per cent. ; compared with benzole, 84·0 per cent. The comparative cheapness of benzine and the fact that it was easy to obtain in large quantities should be taken into consideration. It was therefore not difficult to see why benzine was to-day the chief solvent used for extraction purposes.

Department of Industries  
BOMBAY PRESIDENCY

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# INDIAN CASEIN

## PART II THE PROPORTION OF FAT IN CASEIN

BY  
DATTATRAYA MANJUNATH GANGOLLI  
and  
ANDREW NORMAN MELDRUM

**BULLETIN No. 4**

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MANGALDAS HARKISONDAS, Bookseller, etc., Surat.

## PREFACE.

The first bulletin of the Department of Industries, published in February, 1920, contains an account of the earlier investigations of Mr. D. M. Gangolli and Dr. A. N. Meldrum relating to the preparation of high quality casein in India. The results of their subsequent work are contained in the present publication.

The work of these investigators has enabled the Department recently to open at Anand, under their supervision, a small demonstration factory for the manufacture of casein on a commercial scale. It is hoped that this factory will ultimately result in an extended and improved casein industry.

R. D. BELL,  
Director of Industries.

BOMBAY,  
5th January 1921.

# INDIAN CASEIN.

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## PART II.—THE PROPORTION OF FAT IN CASEIN.

In Part I of this series of papers on Indian Casein—"The Preparation of 'Sulphuric' Casein"—we have considered, in detail, the factors that determine the proportion of acid and of ash-yielding matter in "sulphuric" casein. We have indicated a method, that could be used on a large scale, for making casein so that it shall contain a low proportion of these impurities. A sample of casein that we prepared in July 1919, according to an earlier, though almost a similar process (Part I, page 6, paragraph 18) was sent by the Director of Industries, Bombay, to the Imperial Institute, London. The report which reached us from the Imperial Institute stated that "the casein was regarded by experts as of good quality and it was considered that material equal to the sample would find a ready market in the United Kingdom. . . . There is no doubt that if a product of this quality could be produced on a commercial scale for export much better prices would be obtained than formerly and the reputation of Indian casein would be enhanced."

2. In casein that is intended for industrial use, the impurities, apart from dirt pure and simple, on which its value depends are, water, fat, ash-yielding matter and acid. The more water in a sample the less casein, and further, the more water the greater the liability of the casein to fermentation. In this part of India, it is easy by mere drying in air—except during the monsoon season which lasts less than four months of the year—to produce casein containing a low proportion of water. A high proportion of water and of acid together may encourage decomposition and fermentation of the casein. A high proportion of ash-yielding matter is not always a disadvantage, otherwise "rennet"

casein would be of little value. In "sulphuric" casein, since the acid and ash-yielding matter are easily reduced to small amounts, their presence in large amount encourages the suspicion that the casein has been unskillfully made. The presence of fat is probably a factor on which the value of casein largely depends. The fat in casein is proportional to the amount of fat in the separated milk from which the casein is made. In this paper we consider methods for determining and for reducing the amount of fat in casein. The following paper is therefore divided into two parts:—A. Methods of Analysis; B. Elimination of Fat.

#### A.—METHODS OF ANALYSIS.

3. During the work described in Part I of this series, we had used the customary methods for determining the amount of fat in casein. These consist in treating dry casein with ether, either in Soxhlet's apparatus, or by shaking the casein with the solvent.

4. The method of extraction, using the Soxhlet apparatus, appears to be widely used in the Agricultural Departments of the United States of America. F. L. Browne gives figures which he regards as proof that, for practical purposes, the extraction by ether, of fat, from casein placed in a Soxhlet apparatus, is complete in 8 hours. (*J. Ind. Eng. Chem.*, 1919, 11, 1019-1024.)

Time of extraction in hours.					Fat per cent.
3	..	..	..	..	10.00
6	..	..	..	..	10.45
8	..	..	..	..	10.50
(a) 16	..	..	..	..	10.54
(b) 16	..	..	..	..	10.58

Another method is recommended in Lunge and Keane's "Methods of Technical Analysis," Vol. III, page 328:—The finely powdered casein (10 grams) is shaken for one hour with ether (100 cc.), the ether extract is



filtered and 50 cc. are placed in a small weighed flask; the ether is evaporated and the residue is regarded as fat. These two methods, although they can give comparable results if always used in the same way, are defective in this respect, that the extraction of dry casein, even if the casein is finely ground, can always be regarded as incomplete: it can be objected that fat is left in the interior of the grains.

5. In our work we had used both these methods and had found that they lead to much the same result. But whilst we had found 0.24 per cent. of fat in the casein that was sent to the Imperial Institute, there, the fat was found to be 7.4 per cent. Granting that the method we used does not give absolute results we could not believe that it indicates only 1/30th of the true value, that an absolute method can give 30 times the value we had obtained. We were thus led to investigate methods for determining the amount of fat in casein.

6. Since dry granular casein, on extraction with a solvent, does not yield all its fat, the natural remedy is to dissolve the casein first and then to carry out the process of extraction. We were informed that at the Imperial Institute the method adopted consists of "preliminary digestion with hydrochloric acid followed by extraction with ether." We have followed out this suggestion and by trying various solvents, under different conditions, have been able to arrive at an absolute method for determining fat in casein and, at the same time, to account for the very high result obtained at the Imperial Institute.

7. We used the following solvents:—Hydrochloric acid (concentrated) and sulphuric acid (concentrated); solution of borax and of sodium phosphate; hydrochloric acid, sulphuric acid, sodium hydroxide, ammonium hydroxide, each of 0.5 N strength; barium hydroxide and calcium hydroxide.

8. The use of borax, of sodium phosphate and of calcium hydroxide was abandoned as soon as it was found that these solvents give

rise to a solution that forms an emulsion with ether. In the case of concentrated hydrochloric and sulphuric acids the apparent yield of fat on extraction with ether was high and uncertain. The results in the case of hydrochloric acid were particularly suspicious and the only conclusion we could come to was, that this acid hydrolyses the casein, producing substances that are soluble in ether. The sulphuric acid had a similar effect, though to a less extent. We are pursuing this subject further, and we hope to give the results in a separate paper. At present we can say that casein, when dissolved in concentrated hydrochloric or sulphuric acid, is hydrolysed, producing material that is soluble in ether. On the other hand, when a 0.5 N solution is used, hydrochloric or sulphuric, there was little sign of hydrolysis. We also used dilute solutions of sodium and barium hydroxides, and observed signs either that slight saponification of the fat had occurred or that fatty acid was already present in the casein; the alkaline solution was extracted with ether and then, when the solution was acidified, a small amount of fatty acid was liberated.

9. The casein of which a sample had been sent to the Imperial Institute was again analysed for fat with the following results:—

Solvent.	Fat per cent.
HCl sp. gr. 1.16 .. .. .	(a) 2.28
	(b) 1.94
	(c) 1.46
H <sub>2</sub> SO <sub>4</sub> sp. gr. 1.82 .. .. .	(a) 1.24
	(b) 1.02
HCl 0.5 N .. .. .	0.31
H <sub>2</sub> SO <sub>4</sub> 0.5 N .. .. .	0.29
NaOH 0.5 N .. { Fat .. 0.25 } ..	0.28
	{ Fatty acid 0.03 }
Dry casein shaken with ether .. .. .	0.24
.. in Soxhlet. with ether .. .. .	0.23

10. We submit that these results are as they should be. Strong acids give high and uncertain results because they hydrolyse the casein

and ether extracts fat and hydrolysis product as well. 0.5 N acid and alkali give nearly the same result ; moreover, this result is a little higher than that which is obtained on extracting dry casein with ether.

11. These conclusions were confirmed by further experiments. The following results were obtained on analysing four samples that were obtained in an experiment described in part B, paragraph 18, of this paper :—

Solvent.	Samples.			
	1	2	3	4
HCl sp. gr. 1.16 ..	2.89	0.64	0.26	0.26
HCl 0.5 N ..	2.15	0.49	0.17	0.12
H <sub>2</sub> SO <sub>4</sub> 0.5 N ..	1.99	0.41	0.15	0.08
NaOH 0.5 N ..	1.99	0.37	0.13	0.09
Dry casein shaken with ether ..	1.66	0.22	0.08	0.04

12. A sample of casein, that had been made by a firm in Bombay, was sent to us for analysis. This casein contained a high proportion of fat and was thus advantageous in testing various solvents. The results were as follows :—

Solvent.	Fat per cent.	
H <sub>2</sub> SO <sub>4</sub> 0.5 N ..	..	3.26
NaOH 0.5 N ..	..	3.28
NH <sub>4</sub> OH 0.5 N ..	..	3.29
Ba(OH) <sub>2</sub> 0.5 N supersaturated solution ..	..	3.23
Dry casein shaken with ether ..	..	3.20
.. .. in Soxhlet, with ether ..	..	3.18

13. Further experiments were made with a view to finding which of the possible solvents dissolves casein most rapidly. The results

are summarised in the following table. The amount of casein used was 1 gram in each experiment :—

Reagent.	Strength.	Quantity.	Time during which the casein dissolves.
<i>Alkalies.</i>			
(1) NaOH	.. 0·5 N	15 cc.	2—5 minutes.
(2) NH <sub>4</sub> OH	.. 0·5 N	15 cc.	2—5 „
(3) Ba(OH) <sup>2</sup>	.. 0·5 N*	15 cc.	5—7 „
<i>Acids.</i>			
(1) HCl	.. 0·5 N	25 cc.	3—4 hours.
(2) H <sub>2</sub> SO <sub>4</sub>	.. 0·5 N	25 cc.	3—4 „

14. From the results given in paragraphs 9, 11 and 12, it is clear that 0·5 N hydrochloric acid gives slightly higher results than 0·5 N sulphuric acid. It is possible that the hydrochloric acid causes slight hydrolysis of the casein. Again, the results in paragraph 13 indicate that alkali should be used in dissolving the casein because it acts far more quickly than acid. The details of the method we recommend are as follows :—In a conical separating funnel (capacity 100 cc.) is put the solvent 0·5 N NaOH (15 cc.), and to this is gradually added the finely ground casein (60 mesh, 1 gram). The whole is then shaken vigorously until the casein is completely dissolved. Ether is then added and a rotatory movement is given to the funnel. After allowing the extract to separate, the ethereal layer is transferred through a dry filter paper to a weighed flask and subsequently evaporated to dryness and weighed as fat. In case it is thought desirable to include fatty acid along with fat, the necessity of a second extraction with ether can be avoided by dissolving the casein in alkali and then acidifying by adding sulphuric acid. This acid solution is then extracted with ether as usual.

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\* Supersaturated;

## B.—ELIMINATION OF FAT.

15. It is easy, as we have shown, to control the proportion of ash-yielding matter and of acid in casein, and to reduce these impurities to small amounts. The proportion of fat is less easily controlled, since, in the production on a large scale, it depends almost entirely on the fat left in the separated milk from which the casein is produced. This fact we pointed out in Part I, page 3. Information is not easy to obtain as to the amount of fat left in milk by a good separator, working under the best conditions. As far as we can judge from the extensive series of analyses of casein that F. L. Browne has published, (*loc. cit.*), and from our more limited experience, the proportion of fat in casein, when the separator has been worked efficiently, is always under 0.5 per cent., and the average appears to be 0.25. Casein made in the United States of America and in India, often contains far more fat than this.

16. We have made a number of experiments with a view to reducing further the amount of fat in casein. In the first place, we tried a method that has been recommended, namely, to heat the separated milk at 60°—70° C until a scum is formed. The scum is supposed to contain albumen and fat, and is removed. The milk is then cooled to be converted into casein. An experiment indicated that very little is gained by this process.

	(a) original milk	(b) milk heated to 60°—70° C.
Fat in casein	0.36 per cent.	0.34 per cent.
		Scum 3.401 gr.
		Fat in scum 0.018 gr.

This process, though we gained nothing by it, may be advantageous when the milk contains a large proportion of fat.

17. Knowing the amount of fat in casein it is interesting to calculate back to the amount of fat in the milk, from which the casein was

made. On the supposition that milk contains 3·3 per cent. of casein, the fat in the milk is one-thirtieth of the fat in the casein. This, however, assumes that casein contains all and the whey, none of the fat in the milk. We made an experiment in which we determined the amount of fat (a) in the casein and the whey obtained from a litre of milk and (b) in a litre of the same milk.

Fat in casein	0·84 gr.	
"    whey	0·08 "	
(a) Total fat	0·92 "	(b) Fat in milk 0·93 gr.

Of course, ether was used to extract the fat. The usual assumption made is that ether-soluble matter is fat. Strictly speaking, the experiment proves only that ether-soluble matter in small amount passes into the whey.

18. We have endeavoured to prepare fat-free casein by removing fat from the milk through the agency of petrol. The milk was shaken with petrol in a bottle and the mixture was passed through a separator. This gave petrol and an emulsion on the one hand, and milk on the other. The milk was again treated with petrol and passed again through a separator. In all, four samples of milk were treated so as to get casein, the original milk, and milk that was treated once, twice and thrice with petrol. The amounts of fat in the four samples were determined. The results have been shown in Part A, paragraph 11. We need only repeat that three treatments with petrol led to casein containing 0·09 per cent. of fat.

19. As the process just described was too protracted the petrol was used in another way. Casein was precipitated as usual from separated milk, a sample was taken, dried and analysed; the remainder of the casein was filtered and then, to remove water, was shaken with rectified spirit, filtered, shaken with absolute alcohol and filtered again. The casein was then placed in a bottle and petrol was added and the two were shaken together, using a shaking machine. The casein was filtered, dried and analysed.

				Fat per cent.
Casein untreated	..	..	..	0.44
.. treated with petrol..	..	..	..	0.09

In another experiment casein was precipitated as above and washed with rectified spirit and absolute alcohol. It was then treated three times with petrol. Thus four samples of casein were obtained that had been treated 0, 1, 2 and 3 times respectively. These were dried and analysed.

	0	1	2	3	
Fat	.. 0.21	0.08	0.05	0.04	per cent.

20. We are of opinion that the colour of casein depends greatly on the presence of fat in it. The samples, that we obtained, containing a low proportion of fat, had a very pale green colour, and when the casein was finely ground the colour was almost white. Further, in preparing pure casein for research purposes, we recommend the use of petrol instead of ether in order to remove the fat. Ether is expensive and is liable to contain peroxide which may lead to contamination of the casein. Petrol is cheap, is easily purified and easily passes away from the casein at the end.

AHMEDABAD,  
October 1920.

Department of Industries

BOMBAY PRESIDENCY

# CHINA CLAY DEPOSITS

OF

TALUKA KHANAPUR, BELGAUM DISTRICT

BY

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# THE CHINA CLAY DEPOSITS OF TALUKA KHANAPUR, BELGAUM DISTRICT.

## I.—INTRODUCTION.

Mr. E. R. Fern, Superintendent of the Pottery Department of the School of Art, Bombay, having observed kaolin near Karalgi and Kapoli, Taluka Khanapur, Belgaum District, South India, I was deputed, in November 1920, to investigate these occurrences, in order that their economic value might be ascertained and made known to the Government of Bombay before concessions were given to private individuals.

The quantity of china clay available at Karalgi and Kapoli was determined by sinking a number of prospecting shafts at each locality with the aid of some forty-seven men from one of the settlement colonies in the District, and my thanks are due to Mr. P. R. Cadell, I.C.S., Commissioner, and to Mr. G. Laird MacGregor, I.C.S., Collector of Belgaum, for arranging for this labour to open up the deposits.

I am indebted to Mr. E. R. Fern for making, in his laboratory, a number of chemical and physical tests on the samples of kaolin from Karalgi and Kapoli submitted to him by me from the field; those for Karalgi will be found tabulated on page 12.

My thanks are specially due to Mr. R. D. Bell, C.I.E., I.C.S., Director of Industries, Bombay, for arranging to have the above tests carried out, and for all the help he so courteously gave me during the progress of the research.

There has been no previous literature on the kaolin of Karalgi and Kapoli, and the only reference to the area is by Bruce Foote, who remarks on page 43 of his *Geology of South Mahratta Country, Mem. G. S. I.*, Vol. XII, Pt. 1, that "a kind of granitoid gneiss runs through the town of Khanapur".

## II.—THE DEPOSITS.

### (a) KARALGI.

The kaolin of Karalgi, as will be seen from the sketch plan (Figure 1), occurs in a natural hollow on the side of a bank, the lateritic soil having been washed away by floods of rain during the monsoons, revealing a bed of white china clay which passes gradually through kaolinized gneiss into

the latter in its unaltered state. This hollow has a long oval shape, the main axis of which strikes N.E.-S.W. At the actual junction between the overlying lateritic soil and the underlying kaolinized gneiss, the white clay is very impure and iron stained, being of an ochre-yellow colour ; it becomes, however, purer and whiter at lower and lower horizons until,

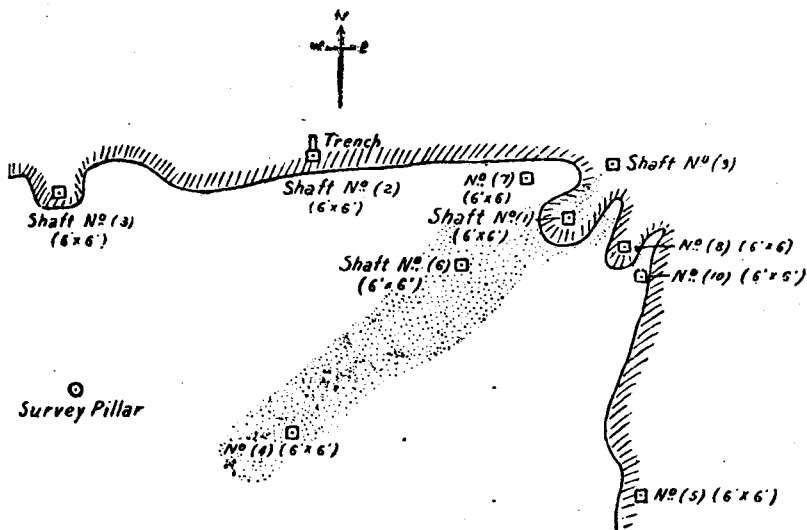


Fig 1. Diagrammatic Sketch Plan of the First Upper River Terrace near Karalgi, and of the Prospecting Shafts Sunk through it to test the kaolin Deposits.

finally, in the trial shaft No. (1) which was sunk here, it passes into pure white china clay of excellent quality. The kaolin bearing ground of this locality (which is included in Revenue Survey Sheet No. 76) is held by Vithal Yeshvant, Patel of Karalgi, and is situated some three miles from the railway station at Khanapur.

Fresh completely unaltered gneiss was not observed in any of the trial shafts, but exposures of it were seen (a) in a field adjoining shaft No. (1) and (b) at a point in the Malpraba river near by. In the latter locality situated a short distance north-west of shaft No. (1), are beds of schistose gneiss forming a bar across the river ; these are traversed by a series of joint planes with an inclination of  $50^{\circ}$  to S.  $70^{\circ}$  W. North-east of shaft

No. (1), on the east bank of the same river, just beyond the bend which it makes to flow northwards after pursuing an easterly direction, and not far from the point where it is joined by a small tributary, is an exposure of slightly kaolinized gneiss, the felspars of which can be seen with the unaided eye to have been partly altered into kaolin. Except for these exposures of the underlying gneiss, the country, in the vicinity of the kaolin at Karalgi, is covered by alluvium. In the midst of the china clay itself, moreover, are fragments of still undecomposed gneiss, the outer skin of which only has been altered into kaolin; these indicate that the china clay of this locality has been formed by the kaolinization of the gneiss. That the kaolin in shaft No. (1) Karalgi has been formed by the decomposition of the upper surface of the muscovite gneiss underlying the lateritic capping is also shown by the china clay containing here and there flakes of white muscovite which escaped decomposition when all the felspars of the original gneiss were decomposed.

In all probability the kaolins of Karalgi and Kapoli have been formed by percolating carbonated surface waters, which have kaolinized the gneiss into which these deposits merge by gradual transition.

#### (b) KAPOLI.

The china clay of Kapoli occurs in (1) land included by Sheet No. 111 of the Land Records Survey, and (2) in Government reserved forest land shown by Sheet No. 93 Land Records Survey. The occurrence is situated four and a half miles from Londa railway station.

The rocks of Kapoli, from which the low grade china clay deposits of that area have been derived, consist of slightly felspathic quartz-muscovite schists with some subordinate grey gneiss, and one of the reasons why there is so little kaolin available there is that the former series of rocks contain comparatively little felspar to become kaolinized.

### III.—QUANTITY.

The quantity of china clay available at Karalgi and also at Kapoli was determined by sinking ten trial shafts at the former and seven at the latter locality to investigate the thickness of each of the beds of kaolin and

their horizontal extent, and to ascertain to what degree the gneiss and felspathic quartz-muscovite-schist forming the country rock had become kaolinized. Those sunk at Karalgi indicate that the quantity of kaolin available there is fairly good; in No. (1) the bed of kaolin is 11' 7" thick, and extends under the ground in a south-south-easterly direction to shaft No. (8), where it increases to a thickness of 17 ft.

A tabulated statement of the trial shafts sunk at Karalgi is given on page 8. These show that the china clay of Karalgi is not in the form of a bed of pure kaolin of uniform thickness and quality extending over a considerable area, but is of the nature of a lenticular somewhat irregular bed of kaolin, whose thickness and quality varies from point to point, consisting at one place of pure kaolin, and at another of slightly kaolinized or almost unaltered gneiss. The bed of kaolin which, as already mentioned, is 11' 7" thick in shaft No. (1), and 17' 0" in No. (8), extends underground for a distance of 240' in a direction S. 49° W. to No. (4), where it diminishes to a thickness of 10' 8". It appears, therefore, that there is a very fair quantity of kaolin available at Karalgi. The shafts, moreover, indicate that when the lenticular bed of kaolin 11' 7" thick in shaft No. (1) is traced for a distance of (a) 47' in a north-westerly direction, it thins out completely before shaft No. (7) is reached; of (b) 56' in a north-easterly direction, it thins out into a few worthless stringers of gritty kaolin in No. (9); of (c) 69' in a direction S. 65° W., it is found to have a thickness of rather more than 6' 3" in No. (6); and of (d) 35' in a direction S. 15° E., it increases in thickness to 17' in No. (8), but thins out entirely in No. (10), after a distance of another 90'. The bed of china clay in No. (1), moreover, thins out completely before shafts Nos. (9), (7), (2), (3), (10) and (5) are reached.

Taking the horizontal area over which the ten prospecting shafts have shown the bed of kaolin to extend underground, which I find to be 8,417.5 sq. ft., and taking the average thickness of the bed to be 10 ft., the total quantity of china clay available at Karalgi, including the lower grade and more gritty varieties, is  $8,417.5 \times 10 = 84,175$  cubic ft., or about 3,750 tons. Owing, however, to the lenticular nature and the somewhat erratic distribution of the kaolin in the gneiss of this locality, it is quite impossible to arrive at an exact figure, and there may, consequently, be

rather more or less than this quantity actually present. I do not think, however, that the quantity available is much less than the figure given above, although it may very well be higher than this, since the lenticular bed of kaolin in the locality tested is probably continued underground in a direction S. 45° W. of shaft No. (4) into the adjoining country.

The quantity of china clay available at Kapoli is indicated by the table of the seven prospecting shafts given on page 10. These indicate that there is no actual bed of kaolin at Kapoli, such as was found at Karalgi, but only slightly kaolinized felspathic muscovite schists and gneiss, which merely contain occasional worthless stringers of gritty kaolin; the kaolin of Kapoli is, therefore, of no economic value.

#### IV.—QUALITY.

The bed of kaolin 11' 7" thick in trial shaft No. (1) Karalgi was sampled by means of a vertical groove 7" wide and 3" deep cut from the top to the bottom of the bed, the china clay so obtained being coned and quartered in the usual way.

As will be seen from the "Table of the Analyses and Physical properties of the china clays of Karalgi," given below on page 12, the kaolin of the locality is of excellent quality, and is of use for the manufacture of porcelain and china ware.

This table shows that since the china clays of shafts Nos. (1), (4), (6) and (8) have silica and alumina percentages which approximate to kaolinite,  $\text{Al}_2\text{O}_3$ ,  $2\text{SiO}_2$ ,  $2\text{H}_2\text{O}$ , ( $\text{SiO}_2$  40·8 per cent.;  $\text{Al}_2\text{O}_3$  39·8 per cent.), they consist of high grade kaolins. The 1·5 per cent. of  $\text{Fe}_2\text{O}_3$  in the kaolins of shafts Nos. (1) and (8) causes the clay to burn a pale yellowish white, while the 2·1 per cent. of  $\text{Fe}_2\text{O}_3$  in the kaolin of shaft No. (6) gives a buff product after firing in the kiln; the action of the lime present in the latter is, however, to diminish the depth of colour by destroying a part of it.

Moreover the table also shows that the quality of the kaolin, so good in shafts (1) and (8), falls off in No. (6), but actually becomes better in No. (4) than it was in No. (1). The analyses also indicate that the quality of the lenticular bed of kaolin, 11' 7" thick in No. (1), is maintained in a S.S.E. direction into No. (8), where it becomes 17' 0" thick.

There is no china clay at Kapoli at all comparable in quality with the pure white kaolin of Karalgi. None of the trial shafts sunk at Kapoli indicate a bed of good pure china clay like that in Nos. (1) and (8) Karalgi, but merely reveal slightly kaolinized ferruginous felspathic muscovite schists and gneisses. The kaolin is tinged a very pale greyish blue, and is iron stained and gritty, all of which very greatly diminish its value for the manufacture of china. Such kaolin would require an excessive amount of levigation to produce a very small quantity of pure clay; this would be an expensive matter, and would, moreover, not completely wash out all the iron-oxide with which the clay is stained.

Very white kaolin is frequently used as a filler of cotton fabrics, as it serves to stiffen them and to give them a surface. In order to see if the Karalgi kaolin was of any value for sizing, an average bulk sample of  $2\frac{1}{2}$  tons of crude kaolin was obtained and sent to Mr. E. R. Fern, who washed out of it the impurities of sand and mica in the specially large levigating trough attached to his laboratories; he produced from it 700 lbs of refined kaolin, which was sent to Messrs. C. N. Wadia & Co., Century Mills, Bombay, who were good enough to make with it a "full sizing test." Mr. J. G. Anderson, General Manager, reporting on the adaptability of the Karalgi china clay for sizing yarn, says that it is somewhat inferior, in its sizing properties, to the china clay which they import from home for the purpose, since the latter is a little whiter in colour and is less brittle and adhesive. He points out, however, that the whiteness of the kaolin could be improved by sun bleaching, and by treatment with a trace of blue colouring matter, and that its brittleness could be remedied by adding to the size a little glycerine or tallow, although this treatment would, of course, somewhat increase its cost. He concludes from his tests that the kaolin is more suitable for finishing cloth than for sizing yarn, since, in the former process, other ingredients are added to whiten the cloth, which, to some extent, would neutralize the objectionable tint of this clay. With all its disabilities, however, the Karalgi kaolin has the following distinct merit in its favour—it has better adhesive qualities than the clay imported from England. On the other hand it sets harder, which may cause the yarn to be harsher and

brittle in shred. Taking everything into consideration there is little doubt that with careful treatment and enterprising business management a market might be obtained for the levigated kaolin of Karalgi as a sizing material for cotton cloth. The kaolin of Kapoli is not pure white like that of Karalgi, but either has a very pale greyish-blue tinge or is of a pale yellowish colour from the contained iron oxide ; it is not, therefore, of any value for the above purpose.

#### V.—TRANSPORT.

The transport facilities of Karalgi are very fairly good since (a) the Malprabha river, flowing eastwards, runs close by (see map), whose channel passes under the railway near Khanapur at a point some  $3\frac{1}{2}$  miles to the west ; at certain times of the year, therefore, when there is sufficient water in the river, small country boats might bear loads of refined kaolin from the china clay occurrence at Karalgi to the railway at Khanapur ; and since (b) the railway at Khanapur is only  $3\frac{1}{2}$  miles due west, in a straight line, from the kaolin at Karalgi. To it should be laid a light tramway, but failing this some two and a half miles of metalled road should be constructed running in a W.S.W. direction from the kaolin occurrence at Karalgi, through, or close to, the village of Jalga, to meet the main road from Khanapur to Nandgad at milestone 18. Along this road motor-lorries might then be used to transport the washed kaolin in casks or gunny-bags to the railway station at Khanapur.



Table of the Prospecting Shafts sunk at

Prospecting shaft (see fig. 1 for the position of each shaft).	Dimensions.	Total depth from surface.	Depth of the upper limit of the bed of Kaolin from the surface.	Depth of the lower limit of the bed of Kaolin from the surface.	Thickness of the bed of Kaolin.
No. (1)	6' x 6'	20' 3"	8' 8"	20' 3"	11' 7"
No. (2)	Pit 6' x 6'; attached trench is 32' x 1' 10".	Pit 6' 4'; attached trench 6' 6"	....	..	Merely a few mi- nute stringers of partly kaolinized gneiss.
No. (3)	6' x 6'	10' 6".	..	....	Do.
No. (4)	Do.	25' 10'	14' 0"	24' 8"	10' 8"
No. (5)	Do.	8' 0"	....	....	Merely a few mi- nute stringers of partly kaolinized gneiss.
No. (6)	Do.	24' 3"	18' 0"	..	More than 6' 3'; total thickness un- known, since the shaft was not sunk deep enough to reach its lower limit.
No. (7)	Do.	19' 7"	....	....	Merely a few mi- nute stringers of partly kaolinized gneiss.
No. (8)	Do.	22' 4"	4' 4"	21' 4"	17' 0"
No. (9)	Do.	6' 9"	....	....	Merely a few stringers of white kaolin.
No. (10)	Do.	7' 0"	...	....	Merely a few mi- nute stringers of pale, sea-green kaolin.

*Karalgi, Khanapur, and their beds of Kaolin.*

Nature and thickness of the "Overburden"	Nature and thickness of the Rock Formation between the lower limit of the "Overburden" and the upper limit of the Kaolin.	Nature of the Rock Formation between the lower limit of the Kaolin and the bottom of the pit.	Remarks.
Granular Laterite: 4' 10".	Yellowish brown clay (highly decomposed gneiss): 3' 10".	Dark yellowish brown ferruginous clay, (highly decomposed gneiss), containing occasional minute stringers of kaolin and partly kaolinized gneiss.	A lenticular bed of excellent kaolin suitable for the manufacture of china ware. The kaolin is very free from grains of quartz and felspar, except near the lower limit of the bed where it passes gradually into partly kaolinized gneiss. At the bottom of this prospecting shaft the lower surface of the lenticular bed of kaolin dips towards No. (8); it was subsequently found to have increased in thickness to 17' 0" in the latter shaft.
Soil and decomposed gneiss.	Partly decomposed gneiss	Partly decomposed gneiss	The prospecting trench attached to the shaft strikes N. 70° E; it merely shows decomposed gneiss with occasional minute stringers of white partly kaolinized gneiss.
Do.	Do.	Do.	The bed of china clay, which is 11' 7" thick in shaft No. (1), has thinned out, entirely before reaching shaft No. (3).
Granular Laterite: 2' 8".	Dark brick-red coloured clay (highly decomposed gneiss): 11' 4".	Pink gneiss showing very slight kaolinization of the felspars.	The shaft is sunk on the wedge-shaped end of the lenticular bed of china clay. At its lower end, against the west wall, is kaolin of very good quality similar to that in Pit No. (1). This lenticular bed of kaolin is seen in the shaft to pass down by gradual transition into partly kaolinized gneiss which grades, at a lower horizon, into almost unaltered pink gneiss.
Soil and decomposed gneiss.	Partly decomposed gneiss	Partly decomposed gneiss	The bed of kaolin 11' 7" thick in shaft No. (1), has thinned out entirely before reaching Pit No. 5.
Granular Laterite: 6' 0".	Yellowish brown clay (decomposed gneiss): 12' 0".	....	The upper boundary of the bed of china clay in this shaft slopes slightly to the west; the bed contains fragments of quartzite, and is not of such good quality as that in prospecting shaft No. (1).
Granular Laterite: 4' 2".	Partly decomposed gneiss	Partly decomposed gneiss	Between the surface and a depth of 10' the gneiss is decomposed into a dark yellowish brown clay, while between the horizons of 10' and 19' 6" the gneiss is less decomposed and contains stringers of kaolinized gneiss.
Soil and decomposed gneiss: 2' 10".	Partly decomposed gneiss: 1' 6".	Brown clayey ferruginous decomposed gneiss, (practically the same as that below the kaolin bed of shaft No. (1)).	This shaft is sunk in the middle of a natural hollow in the ground formed by the heavy rains during the monsoons. The china clay is very pale sea-greenish-white in colour.
Do.	Do.	Partly decomposed gneiss	The bed of kaolin, 11' 7" thick in shaft No. (1), when traced for 56' in a north-easterly direction, thins out into a few worthless stringers of gritty kaolin in prospecting shaft No. (9).
Do.	Do.	Do.	The bed of kaolin, 17' 0" thick in shaft No. (8), thins out almost entirely in pit No. (10).

Table of the Prospecting Shafts

Prospecting shaft (see fig. 1 for the position of each shaft).	Dimensions.	Total depth from surface.	Depth of the upper limit of the Kaolin from the surface.	Depth of the lower limit of the Kaolin from the surface.	Nature and thickness of the Kaolin.
No. (1)	8' x 6'	13' 6"	....	..	Partly kaolinized pale sea greenish white felspathic muscovite schists, containing occasional stringers of impure gritty kaolin; no actual bed of kaolin is present.
No. (2)	8' x 7'	19' 0"	..	....	Partly kaolinized somewhat iron-stained felspathic quartz muscovite schists, containing minute stringers of gritty kaolin; no actual bed of china clay is present.
No. (3)	8' x 6'	13' 3"	..	..	Small lenticles of pale bluish white-kaolin; no actual bed of china clay is present.
No. (4)	Do.	10' 6"	....	....	....
No. (5)	8' x 6' 6"	14' 4"	3' 4"	5' 7"	A somewhat irregular layer, 2' 3" thick, of impure gritty kaolin occurring immediately under a capping of laterite.
No. (6)	8' x 6'	25' 0"	11' 6"	23' 0"	A bed of pale greenish-white impure gritty kaolin, which is somewhat stained with iron oxide, and has a thickness of 11' 6".
No. (7)	6' x 6'	21' 0"	8' 0"	12' 0"	Soft decomposed, slightly kaolinized, and somewhat iron stained gneiss and felspathic muscovite schist containing minute stringers of gritty kaolin which form a bed of impure china clay 4' 0" thick.

*sunk at Kapoli, Khanapur.*

Nature and thickness of the "Overburden".	Nature and thickness of the Rock Formation between the lower limit of the "Overburden" and the upper limit of the Kaolin.	Nature of the Rock Formation between the lower limit of the Kaolin and the bottom of the pit.	Remarks.
Soil and decomposed gneiss.	Partly kaolinized felspathic-muscovite schists.	Partly kaolinized felspathic muscovite schist and ochre-yellow iron-stained decomposed gneiss	The kaolinized felspathic muscovite schists, besides having small stringers of impure gritty kaolin, which become more numerous in depth, contain stains of brown oxide of iron, and areas of brown ferruginous completely unkaolinized felspathic muscovite schist.
oil 1' 6"	Do.	Partly kaolinized felspathic muscovite and chlorite schists.	At 10' from the surface is a zone 1' 8" deep of reddish-brown, highly iron stained and gritty very slightly kaolinized felspathic quartz-muscovite-schist. Immediately below this, and between the 11' 8" level and the bottom of the shaft is a zone of contorted, unkaolinized, slightly felspathic quartz muscovite schist, which passes into pale emerald green chloritized quartz muscovite schist, containing "eyes" of felspar and no kaolin, near the bottom of the shaft.
A 3' 5" layer of laterite capped by 4" of soil.	Slightly kaolinized gneiss	Soft decomposed deeply iron-stained kaolinized gneiss.	One of the largest lenticles of kaolin measures 2' 6" x 4' 8". These are more or less iron stained in places with patches of yellowish-brown iron oxide, and are also very impure and gritty containing many fragments of still unkaolinized felspar and grains of quartz. The junction between the cap of laterite and the underlying slightly kaolinized gneiss appears to be the channel along which the circulating carbonated surface-waters gained entrance to the latter to bring about kaolinization. The iron staining increases below the 8' 9" horizon. The quantity of kaolin present in the altered gneiss becomes less and less at lower and lower horizons.
Capping of laterite: 4' 6".	.....	.....	No kaolin was met with in this shaft, but only pale emerald-green plastic clay derived from epidiorite.
Soil and laterite: 3' 4" thick.	No intervening rock	Slightly kaolinized and partly iron-stained gneiss passing down into unaltered gneiss with porphyritic crystals of pink orthoclase.	The china clay is not worth sampling, since it consists of a bed of impure gritty kaolin.
A 2' 0" layer of laterite capped by 9" of soil.	Partly kaolinized and iron stained felspathic quartz muscovite schists.	Ochre-yellow soft decomposed clayey gneiss.	The percentage of kaolin, in the partly kaolinized felspathic quartz muscovite schists, gradually increases at lower and lower horizons as far as the 11' 6" level.
Laterite: 5' 0" thick	Decomposed, slightly kaolinized, and somewhat iron stained gneiss and felspathic muscovite schists, which form an ochre-yellow clay.	Decomposed, slightly kaolinized, and somewhat iron-stained gneiss and felspathic muscovite schists, which form a dark reddish-ochre clay.	No pure white kaolin is present here, for it is either of a light bluish-grey colour or iron stained.

*Table of the Analyses and Physical Properties*

Locality.	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	F <sub>2</sub> O <sub>3</sub> .	CaO.	Loss on ignition.	Fine clay produced after Levigation.	Residue after Levigation.
Kaolin of prospecting Shaft No. 1, Karalgi.	44.9	39.1	1.5	2.5	11.7	Per cent. 35.8	Mostly mica with some fine quartz sand.
Do. No. 4 ..	44.0	41.3	0.5	1.5	11.9	19.15	Nearly all mica ..
Do. No. 6 ..	45.5	38.4	2.1	2.3	11.1	17.95	Mostly mica ..
Do. No. 8 ..	44.2	41.5	1.5	1.0	11.9	16.75	Do. ..
Kaolin from near prospecting Shaft No. 1, Karalgi.	45.0	39.0	1.5	3.0 (Traces of MgO present).	11.0	..	Mica and quartz sand.

*of the China Clays of Karalgi, Khanapur.*

Colour of levigated sample.	Quality of levigated sample.	Plasticity.	Effect on Drying.	Effect on Firing to 1050°C.	Refractoriness at 1300°C.	Colour on Firing to 1050°C.	Porosity.	Hardness.	Remarks
White (slightly creamy).	Good quality.	Non-plastic.	Does not crack.	Does not crack.	Soft and porous with no signs of fusion.	Very pale cream almost white.	Porous.	Fairly hard.	May be employed for the manufacture of common china and earthenware, and as sizing material for cloth. Of no use for modelling, as it is not plastic.
White ..	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	May be used for the manufacture of good china and porcelain, and as sizing material of good quality for cloth and paper making.
Dark cream, nearly yellow.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Not of much use for pottery or porcelain except for the very lowest and cheapest grades. Of no value as a sizing material.
Light cream ..	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Will serve the same purpose as the kaolin of prospecting Shaft No. (1), Karalgi.
White ...	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.

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