the zone of *H. subglobosus* of Wiltshire and Berkshire, but has not yet been reported from Hampshire, Kent, Isle of Wight, Dorset, Oxfordshire, Buckinghamshire, or Hertfordshire.

With regard to *Acanthoceras rotomagensis* it cannot be regarded as a better guide than *H. subglobosus*, for in many of the southern counties it is fairly common in the zone of *A. varians*. North of the Thames, however, it seems to be restricted to the higher zone until we reach Norfolk, where it again occurs in the zone of *A. varians*, as it does also in Yorkshire.

There remains only the larger form of *Discoidea cylindrica*, a species which is generally much more common in the upper part of the Lower Chalk than in the lower part. In the south of England it has only been recorded from the zone of *A. varians* in Dorset and Somerset, and by Mantell from Hamsey in Sussex (not since confirmed). It is indeed a common fossil of the lower zone in Yorkshire, Lincolnshire, and Norfolk, but the form there found is the depressed variety, and if any constant structural differences can be found to distinguish this variety from that which prevails in the higher zone the latter might perhaps be utilised as an index for that zone.

To sum up, therefore, it would seem that our knowledge of the distribution of the fossils of the Lower Chalk is not yet sufficiently complete to enable us to decide on any substitute for *H. subglobosus* as an index. It may be that *Haploceras Austeni* would be a better one in spite of its occasional occurrence lower down, or it may be that the taller hemispheric variety of *Discoidea cylindrica* will be preferable. More information is required about both, and meantime I am sure that it would be undesirable to make any alteration in the current nomenclature, and I do not think that the terminology proposed by Mr. Bosworth would at any time be an improvement.

V.—The Source of the Waters of Geysers.

By J. Malcolm Maclaren, B.Sc., F.G.S.,
Geological Survey of India, Calcutta.

PROFESSOR SUESS has somewhat recently stated his belief that the waters of all geysers and boiling 'pulsating' springs and of some mineral springs are of 'hypogene' or direct magmatic origin (Abstract Geog. Journ., vol. xx, p. 518). I am unfortunately unable in this backwater of science to verify the abstract by reference to the original (Gesell. Deutsch. Naturforscher und Aertze, 1902). With his belief, however, several prominent Continental and American geologists have expressed their concurrence, and some have indeed amplified the hypothesis to cover the origin of metalliferous deposits near igneous contacts. For example, W. H. Weed (Trans. Amer. Inst. M.E., vol. xxxiii, p. 746) says:—

"I hold that the metallic contents of such veins are not gathered by ordinary meteoric water, as maintained by Van Hise. The water content of the sedimentary rocks (ground-water) present at the time of eruption was expelled by contact-metamorphism. The ore-forming solutions were in part of direct igneous origin (i.e. primitive or igneogenous; the geyser waters of Iceland, New Zealand, and the Yellowstone regions are probably mainly of this character, as maintained by Suess); these primitive hot vapors and waters rise and penetrate the zone of circulating meteoric waters, heating the latter and charging them with both metallic salts and with fluorine, chlorine, bromine, and other mineralizing agents."

Recent geyser phenomena in New Zealand have led me to doubt more than ever the validity of this inference of Suess. New Zealand contains one of the most active of fumarolic areas, and, curiously enough, the life-history of its greatest geyser—the greatest also that the world has yet known—is strikingly illuminative of the subject under discussion. For confirmatory details of the history of this geyser I am indebted to the courtesy of Mr. Colin Fraser, of the New Zealand Geological Survey. Waimangu Geyser was discovered in January, 1900, but it had doubtless been in existence for a short time prior to that date. Its basin was then some 130 feet long and 80 feet wide, at ordinary times full of black muddy water. Although it played almost daily, its eruptions were most irregular in character, sometimes expending their energy in a single outburst, hurling a mass of water estimated at 800 tons to a maximum height of 1,500 feet, at other times playing lightly and intermittently for five to six hours. The intervals between eruptions were rarely more than 30 hours. For more than four years after its discovery Waimangu was in active eruption, but during July and August, 1904, it remained quiescent for nearly two months. After this period of inactivity it recommenced its eruptions with unabated and indeed often increased energy, and so continued until 31st October, 1904, when, with the exception of a feeble eruption on the following day, it ceased spouting, and now remains dormant or is extinct—a flowing pool with a temperature of 130° F.

The modern history of Tarawera Lake, four miles to the north-east of Waimangu, is important in this connection. The explosive eruption of Tarawera Mountain in June, 1886, threw a great ash barrier across the valley which formed the natural outlet for the waters of Lake Tarawera. (For a graphic description of this Tarawera rift area, *vide* Geog. Journ., April, 1906.) The level of the lake at once rose some 28 feet, and after some time, as the outlets through the ash barrier became choked with débris, continued to rise still further. By the end of October, 1904, the waters had risen another 14 feet. At that height and on the 1st November, *the day on which Waimangu last played*, the waters overtopped the barrier. On the following day the level of the lake had fallen three feet, and on the 3rd November the barrier was carried away. The waters of the lake rushed over the Tetauahape escarpment and escaped by an old channel at the rate of more than a million and a half cubic feet per minute, forming, for the few days they lasted, a stupendous cataract. The level of the lake is now eleven feet below the maximum height of 1904, and its waters now escape by the normal subterranean channels, which from Maori legends are known to have been in existence for centuries.

In Waimangu Geyser itself there has been no recrudescence since the breaking away of Lake Tarawera, and in the immediate vicinity there has been one outburst only. This took place on 21st February, 1906, at Frying Pan Flat, but lasted only a few hours. Frying Pan Flat is, however, an old geyser crater that had been in eruption during the period of Waimangu activity. Thermal relief along the Tarawera rift is now effected by comparatively mild eruptions, the character of which would seem to indicate expulsion from slowly filling subterranean reservoirs.

Other large geysers in the New Zealand area show or have shown a degree of dependence on superficial waters. Dr. Wohlmann, Government Balneologist, instances the case of the Crow's Nest Geyser at Taupo, on the banks of the Waikato River, near its emergence from Lake Taupo. When the Waikato River is in flood the Crow's Nest Geyser plays every 40 minutes. With low waters the interval is increased to two hours. At Orakeikorako, some fifteen miles to the north and also on the banks of the Waikato River, the great geysers last played when the Waikato River was abnormally high. Thermal manifestation at Orakeikorako has since been confined to hot springs.

Every gradation from Waimangu through boiling springs to faintly bubbling warm pools are known in the New Zealand area, and it seems impossible to make any genetic distinction between the most active and the more lethargic members of the series. Yet some of the latter are obviously dependent for their waters on surface supplies. The heat necessary to create the motive force of these geysers lies certainly at no great depth. For many years after the 1886 eruption it was possible to char wood by plunging it into a crevice in the ash beds. While, therefore, the heat supplied to the geysers may certainly be considered magmatic, it is nevertheless directly applied, and is not carried to the geyser tube by magmatic waters and vapours such as have been called into existence in the passage quoted in the first paragraph of this communication.

Nor even in this New Zealand region, the evidence from which points to the meteoric origin of geysers and hot springs, is the evidence of contemporaneous metallic deposition lacking. By the courtesy of the New Zealand Geological Survey I am enabled to publish two interesting analyses, or rather assays, made by the Colonial Analyst, of fumarolic deposits from Whakarewarewa, immediately south of Rotorua. Siliceous sinter taken from the sides of a trough used to conduct hot water from a large pool behind the Geyser Hotel gave —

	dwts.	grs.	
Gold	0	12	per ton.
Silver	15	3	,, ,,

while a sulphurous sinter formed on the edge of the spring showed :—

	ozs.	dwts.	grs.	
Gold	0	1	4	per ton.
Silver	4	0	18	,, ,,

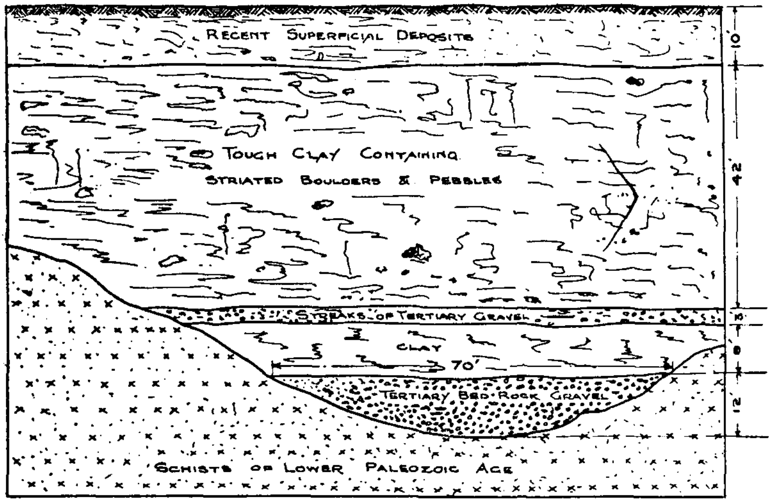
both most suggestive results.

While it is at once admitted that the foregoing facts are not in themselves sufficiently correlated to justify the assumption of a meteoric origin for all geysers and most metalliferous solutions, they may nevertheless be considered sufficiently suggestive to give pause to the most imaginative of magmatic secretionists. In view of the undoubted connection between heated waters and ore deposition, further detailed and scientific study of these fumarolic areas is greatly to be desired.

VI.—Some Further Considerations of the Genesis of the Gold Deposits of Barkerville, B.C., and the Vicinity.

By Austin J. R. Atkin, Esq.

SINCE the publication of my paper "The Genesis of the Gold Deposits of Barkerville,"[1] the frequency with which it has been suggested to me that the gold in the placers spoken of might have been precipitated *in sitû* has led me to place before you the reasons for ascribing to it the origin therein stated.



SECTION OF FILLING, ANCIENT CHANNEL, LOWER WILLIAMS CREEK. CARIBOO. B. C.

In propounding the theory of precipitation to explain the occurrence of nuggets in the Australian 'leads' Professor Newberry took into account the fact that it was only at considerable distances from the source of the leads that the larger nuggets were found. He also noted that the greatest accretions of gold were where the wood found in these old channels was most abundant; that as a rule the gold contained a nucleus of iron; that it was finer in

[1] Quart. Journ. Geol. Soc., vol. lx (1904), pp. 389–393.