

"GEOLOGI"

Nasr. "Islamic...", s. 87, 141-143, 244-245

Geologi (Ter 4)

Papers, 1969, 29–52. (A discussion of Paul Hertz's theory of logical deduction.)

— (1935) 'Untersuchungen über das logische Schließen', *Mathematische Zeitschrift* 39: 176–210, 405–565; repr. Darmstadt: Wissenschaftliche Buchgesellschaft, 1969; trans. 'Investigations into Logical Deduction', in *The Collected Papers*, 1969, 68–131. (Gentzen's doctoral dissertation, including the calculi of natural deduction and sequents, and the consistency proof for arithmetic without complete induction.)

— (1936a) 'Die Widerspruchsfreiheit der reinen Zahlentheorie', *Mathematische Annalen* 112: 493–565; repr. Darmstadt: Wissenschaftliche Buchgesellschaft, 1967; trans. 'The Consistency of Elementary Number Theory', in *The Collected Papers*, 1969, 132–213. (Includes a discussion of finitism and the introduction of transfinite induction.)

— (1936b) 'Die Widerspruchsfreiheit der Stufenlogik', *Mathematische Zeitschrift* 41 (3): 357–66; trans. 'The Consistency of the Simple Theory of Types', in *The Collected Papers*, 1969, 214–22. (Discusses the consistency of the simple theory of types.)

— (1938) *Die gegenwärtige Lage in der mathematischen Grundlagenforschung: neue Fassung des Widerspruchsfreiheitsbeweises für die reine Zahlentheorie*, Leipzig: Hirzel; part 1 repr. in *Deutsche Mathematik* 3: 255–68, 1939; repr. Darmstadt: Wissenschaftliche Buchgesellschaft, 1969; trans. 'The Present State of Research into the Foundations of Mathematics', in *The Collected Papers*, 1969, 234–51. (The first part gives an excellent account of the state of proof theory in the 1930s.)

— (1943) 'Beweisbarkeit und Unbeweisbarkeit von Anfangsfällen der transfiniten Induktion in der reinen Zahlentheorie', *Mathematische Annalen* 119 (1): 140–61; trans. 'Provability and Nonprovability of Restricted Transfinite Induction in Elementary Number Theory', in *The Collected Papers*, 1969, 287–308. (Gentzen's post-doctoral thesis.)

References and further reading

Prawitz, D. (1965) *Natural Deduction: A Proof-Theoretical Study*, Stockholm Studies in Philosophy 3, Stockholm, Göteborg and Uppsala: Almqvist & Wiksell. (A classic study of Gentzen's logic and its development up to 1965.)
Vihari, P. (1995) 'The Last Months of Gerhard Gentzen in Prague', *Collegium Logicum* 1: 1–7. (An account of Gentzen's imprisonment.)

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GEOLOGY, PHILOSOPHY OF

In the mid-1960s, geology underwent a conceptual revolution. Prior to that time, most geologists believed that the continents and oceans were fixed and permanent, the basic features of the earth's crust. Subsequently they came to agree that the earth was covered by rigid plates, thin in relation to the earth's diameter, in which the continents were embedded like logs in icebergs. It was the creation, movement and destruction of these plates that were responsible for the mid-ocean ridges, the areas of mountain building and earthquake activity, and the deep ocean trenches.

This conceptual revolution also marks a shift in the philosophy of geology. From the early nineteenth century, the chief philosophical question posed by geology was whether a historical science encountered special epistemic problems, a question that was usually answered by invoking the principle of uniformitarianism. In its strict form this stated that the only kind and intensities of causes that could be used to explain past geological phenomena were those that could be directly observed. Many sloppier formulations were invoked under the same name. Since the revolution, philosophers have turned to geology chiefly to use the revolution to exemplify or challenge one or another theory of scientific change.

- 1 Geology as a historical science: uniformitarianism
- 2 Scientific change and the plate tectonic revolution

1 Geology as a historical science: uniformitarianism

Early in the nineteenth century, geologists, who had previously concerned themselves primarily with the location and chemistry of economically valuable ores, began instead to concentrate on unravelling the earth's history. For the next century-and-a-half, the major issue in philosophy of geology was what it was to be a historical science. Most of the hard thinking about this was done by geologists, not philosophers.

Often cited in this regard is James Hutton, the late-eighteenth-century Scottish geologist and natural philosopher, who coined the phrase that the processes of geology showed 'no vestige of a beginning, no prospect of an end'. But in fact the major analysis of geology as a historical science was advanced by Charles Lyell, the British geologist, in his three-volume *Principles of Geology* (1830–3). Although Lyell himself did not call this analysis uniformitarianism, the Victorian philosopher-scientist William Whewell dubbed it so in the *Quarterly Review* in 1832. What Lyell had suggested was: one, that the laws of nature have not changed over time (law uniformitarianism); two, that the kinds of cause

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