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# The Contribution of Ibn Sina (Avicenna) to the development of Earth Sciences


**Author:** **Munim M. Al-Rawi** PhD
**Chief Editor:** **Professor Salim Al-Hassani**
**Editor:** **Salah Zaimeche** BA, MA, PhD
**Production:** **Ahmed Salem** BSc



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**FSTC Limited**
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**Web: http://www.fstc.co.uk Email: info@fstc.co.uk**

# THE CONTRIBUTION OF IBN SINA (AVICENNA) TO THE DEVELOPMENT OF EARTH SCIENCES

**by Munim M. Al-Rawi** PhD

## Abstract / Highlights

The Muslim Civilization was outstanding in its natural look towards the universe, man and life. Muslim scientists thought and wondered about the origin of minerals, rocks, mountains, earthquakes and water, etc. Ibn Sina (981 - 1037 C.E.), better known in the West as Avicenna, has a leading contribution in his famous Encyclopaedia of Philosophy and Natural Sciences "Kitab AI-Shifa" (the Book of Cure, Healing or Remedy from ignorance). In Part 2, Section 5, the Article on Mineralogy and Meteorology, he presented a complete coverage of knowledge on what happens on the Earth in six chapters:

1. Formation of mountains;
2. The advantages of mountains in the formation of clouds;
3. Sources of water;
4. Origin of earthquakes;
5. Formation of minerals;
6. The diversity of earth's terrain.

His knowledge on Meteorology, or what happens above the Earth, is also covered in six chapters:

1. Clouds and rain;
2. Causes of rainbow;
3. Features associated with sun reflection on clouds, and rainbow;
4. Winds;
5. Thunder, lighting, comets and meteorites;
6. Catastrophic events which effects the surface of the earth.

In Kitab Al-Shifa, Avicenna had presented fundamental principles of Geology in terms of Earth processes, major events and long geologic time. Those principles were later known in the Renaissance of Europe as the law of superposition of strata, the concept of catastrophisim, and the doctrine of uniformitarianism*. Those concept were embodied in the Theory of the Earth by James Hutton in the Eighteenth century C.E. Kitab AI-Shifa, was also known in the Renaissance of Europe. It was an inspiring source of thought to the founders of geological thought in Europe (such as Leonardo Da Vinci and Steno in the Seventeenth C.E., and most probably later on James Hutton in the Eighteenth C.E.).

* Uniformitarianism: is the concept that the earth's surface was shaped in the past by gradual processes, such as erosion, and by small sudden changes, such as earthquakes, rather than by sudden divine acts, such as Noah's flood.

## Introduction

It can be rightfully said that Ibn Sina (Avicenna, 981 - 1037 C.E.) was a true product of the Muslim Civilization in its climax of scientific growth. He contributed to natural sciences (which he called it Attabieyat) along with other natural philosophers such as Ikhwan AI-Safa, AI-Biruni and many others. Avicenna's work in "Kitab AI-Shifa" (the Book of Cure, Healing or Remedy from ignorance), the famous Encyclopaedia of Philosophy and Natural Sciences had influenced European scientists during the Renaissance because of its being in a comprehensive and encyclopaedic form. Although Avicenna is better known in Medicine and Philosophy, he was less known in Earth Science. This is because of the nature of the Earth Science itself, and its history of development in Europe. Earth Science was only known as "Geology" in Europe since the Seventeenth century C.E. The purpose of this rather concise account is to highlight Avicenna's contribution to the development of Earth sciences, and seeking to answer the following points:

1. To close the gap in the history of Geology, which reflects human thought upon the nature of the Earth.

2. To show that Avicenna's original contribution was not the product of an earlier Greek thought.

3. To show that fundamental principles of Geology were put forward many centuries before the Renaissance in Europe.

It is intended to present Avicenna's principles of Earth Science as he put it in Kitab Al-Shifa, Part 2, Section 5, the Article on Mineralogy and Meteorology, the chapter on Origin of Mountains. Those principles were already known by some historians of Geology, such as Adams (1938), Dennis (1972), Kemmel (1973) and among historians of science such as Sabra (1976) and Wickens (1976).

Unfortunately, some historians of Geology attributed Avicenna's knowledge of Earth science to the Greek science, such as Kemmel (1973). However, in a rather philosophical account titled the Discovery of Time, Toulumin and Goodfield (1965), have acknowledged Avicenna's contribution in the field of geologic time:

> *"Around A.D. 1000, Avicenna was already suggesting a hypothesis about the origin of mountain ranges, which in the Christian world, would still have been considered quite radical eight hundred years later".*

* * *

## Avicenna's contribution to Earth Sciences

Avicenna's area of study is located in the Former Soviet Republic of Uzbakistan, North of Afghanistan (Figure 1). It comprises the mountainous area around the Amur Darya River (previously known as the Oxus River or the Ancient River Gihoun). The area presently stretches along the northern mountains of Afghanistan and Turkmenistan, as well as Western Uzbakistan. Geologically, the area studied consists of sedimentary rocks belongs to different geological ages, and Recent alluvium deposits along the Amur Darya River.

As Adams (1938, p.333-335) put it;

> *Avicenna's views concerning the origin of mountains which, as will be noted, have a remarkably modern tone, may be best presented in a translation of his own words by Holmyard and Mandeville (Avicennae de Congelatione et Conglutinatione Lapidum, being sections of the Kitab al-Shifa. Librairie Orientaliste, Paul Geuthner, 1927, p. 18) ":*
>
> *"We shall begin by establishing the condition of the formation of mountains and the opinions that must be known upon this subject. The first (topic) is the condition of the formation of stone, the second is the condition of the formation of stones great in bulk or in number, and the third is the condition of the formation of cliffs and heights".*

In other words, Avicenna had established the fact that for the formation of mountains, we have to understand the ways that stones (rocks) are formed, then the manner of which rock sequences are formed, and finally the process of which mountains are formed after uplift and erosion. It is worthwhile then, to elaborate on Avicenna's description on the origin of mountains as it fundamental principle in the formulation of geological sciences in Europe. Figure 2 illustrates Avicenna's field observations and interpretations.

### 1. Formation of Stones (Rocks):

Avicnna has established three origins for the formation of stone (rock), being from water (chemical), mud (detrital) or fire (igneous). Presently, these origins are known as sedimentary and igneous. Avicenna did not know the third metamorphic origin (alteration from sedimentary and igneous rocks), because it was only known after the advent of microscope in Europe.

> *"We say that, for the most part, pure earth does not petrify, because the predominance of dryness over (i.e. in) the earth, endows it not with coherence but rather with crumbliness. In general, stone is formed in two ways only (a) through the hardening of clay, and (b) by the congelation of waters... Stone has been formed from flowing water in two ways (a) by the congelation of water as it falls drop by drop or as a whole during its flow, and (b) by the deposition from it, in its course, of something which adheres to the surface of its bed and (then) petrifies. Running waters have been observed, part of which, dripping upon a certain spot, solidifies into stone or pebbles of various colours, and dripping water has been seen which, though not congealing normally, yet immediately petrifies when it falls upon stony ground near its channel. We know therefore that in that ground there must be a congealing petrifying virtue which converts the liquid to the solid.... Or it may be*

*that the virtue is yet another, unknown to us".... Stones are formed, then, either by the hardening of agglutinative clay in the sun, or by the coagulation of aquosity by a dessicative earthy quality, or by reason of a desiccation through heat".*

Regarding fossils, which were found within stones, Avicenna gave an explicit explanation of their origin from the petrifaction of plants and animals by mineralizing and petrifying virtue within stones:

*"If what is said concerning the petrifaction of animals and plants is true, the cause of this (phenomenon) is a powerful mineralizing and petrifying virtue which arises in certain stony spots, or emanates suddenly from the earth during earthquakes and subsidences, and petrifies whatever comes into contact with it. As a matter of fact, the petrifaction of the bodies of plants and animals is not more extraordinary than the transformation of waters"…*

**2. Formation of Stones Great in Bulk (Rock Sequences):**

Translation by the author from the Arabic by Montasir et al (1965), of the chapter on the origin of mountains in Kitab Al-Shifa, which is not included in Adams (1938):

*"The formation of stones in abundance is either at once due to intense heat (probably referring to arid climate) over vast mud area; or little by little through sequence of days. … most probably from agglutinative clay which slowly dried and petrified during ages of which we have no record. It seems likely that this habitable world was in former days uninhabitable and, indeed, submerged beneath the sea. Then becoming exposed little by little, it petrified in the course of ages the limits of which history has not preserved; or it may have petrified beneath the waters by reason of intense heat confined under the sea. … It is for this reason, i.e. that the earth was once covered by the sea, that in many stones when are broken , are found parts of aquatic animals, such as shells, etc. … It is not impossible that the mineralizing virtue was generated there, i.e. in the petrifying clay, and aided the process, while the waters also may have petrified",* (probably referring to the chemical precipitation of cement from interstitial water).

Avicenna has clearly recognised that the formation of rocks in bulk is a slow process.

**3. Formation of Cliffs and Heights (Mountains):**

Avicenna went into describing the process of uplift and erosion in the formation of mountains, after the formation of stones and rock sequences:

*"The formation of heights is brought about by (a) an essential cause and (b) an accidental cause. The essential cause (is concerned) when, as in many violent earthquakes, the wind which produces the earthquake raises a part of the ground and a height is suddenly formed. In the case of the accidental cause, certain parts of the ground become hollowed out while others do not, by the erosive action of winds and floods which carry away one part of the earth but not another. That part which suffers the action of the current becomes hollowed out, while that upon which the current does not flow is left as a height. The current continues to penetrate the first-formed hollow until at length it forms a deep valley, while the area from which it has turned aside is left as an*

*eminence. This may be taken as what is definitely known about mountains and the hollows and passes between them…The abundance of stone in them is due to the abundance, in the sea, of clay, which was afterwards exposed. Their elevation is due to the excavating action of floods and winds on the matter which lies between them, for if you examine the majority of mountains, you will see that the hollows between them have been caused by floods. This action, however, took place and was completed only in the course of many ages, so that the trace of each individual flood has not been left; only that of the most recent of them can be seen".*

Avicenna then summarises his views on the origin of mountains:

*"At the present time, most mountains are in the stage of decay and disintegration, for they grew and were formed only during their gradual exposure by the waters. Now, however, they are in the grip of disintegration, except those of them which God wills should increase through the petrifaction of waters upon them, or through floods which bring them a large quantity of clay that petrifies on them".*

Finally, Avicenna outlines the fundamental principle of superposition of strata, which later in the history of Geology became the Law of Superposition of Strata by Nicolaus Steno in the Seventeenth century C.E.:

*"It is also possible that the sea may have happened to flow little by little over the land consisting of both plain and mountain and then have ebbed away from it. ... It is possible that each time the land was exposed by the ebbing of the sea a layer was left, since we see that some mountains appear to have been piled up layer by layer, and it is therefore likely that the clay from which they were formed was itself at one time arranged in layers. One layer was formed first, then at a different period, a further layer was formed and piled, upon the first, and so on. Over each layer there spread a substance of different material, which formed a partition between it and the next layer; but when petrifaction took place something occurred to the partition which caused it to break up and disintegrate from between the layers (possibly referring to unconformity). … As to the beginning of the sea, its clay is either sedimentary or primeval, the latter not being sedimentary. It is probable that the sedimentary clay was formed by the disintegration of the strata of mountains. Such is the formation of mountains."*

* * *

## The Development of Earth Sciences in Europe

The Development of Geology as a distinct science in Europe, was a product of the development of certain principles and concepts on Earth in about three stages.

1. The Pre-Christian stage.
2. The Formative stage between Fourteenth to Seventeenth centuries C.E.
3. The development of geologic theories during the Eighteenth and Nineteenth centuries C.E.

During formative and development stages, the scientific debate formulated the following principles and concepts:

1. Meaning of fossils.
2. The continuation of geological processes or the doctrine of uniformitarianism.
3. Law of superposition of strata.
4. Long geologic time.
5. Concept of catastrophisim.

The history of Geology in Europe sees Leonardo Da Vinci (1452-1519), as a near universal genius:

> *"Da Vinci's notebook show that he clearly appreciated the nature of fossils, of erosion, transport and deposition, and of shifting of seas and land. Free from dogmatic misconceptions, he was a naturalist far ahead of his time. Unfortunately, his geologic ideal were lost for several centuries",* (Mears 1978)

Those very ideas were embodied in Avicenna's work in Kitab Al-Shifa and the work of many other Muslim natural scientists, such as Ikhwan Al-Safa and Al-Biruni.

Nicolaus Steno (1638-1687) supposedly came with the early fundamental concepts of Historical Geology, the law of superposition of strata. "Steno's conclusion to the formation of a stratigraphic succession can be condensed as follows (Kummel 1973):

1. *"A definite layer of deposit can form only upon a solid base;*
2. *The former stratum must therefore be consolidated before a fresh deposit is precipitated upon it;*
3. *Any one stratum must either cover the whole earth or be limited laterally by other solid deposit;*
4. *Since, while a deposit is accumulating, only the water from which it precipitated is above it, the lower layers in a series of strata must be older than the upper".*

The Eighteenth century C.E. saw the applications of the law of superposition of strata, as well as some controversial views on the earth's history. Abraham Werner (1749-1817) came with a theory that relates the origin of all rocks to water. That theory was also known as the Neuptunist theory, which had an overwhelming, support at that time in Europe. During that time, another distinguished investigator, James Hutton (1726-1797) who contributed some fundamental concepts, which are very important in the history of Geology.

> *"Hutton demonstrated the plutonic origin of granite and recognised the significance of angular unconformities. A few scientists before him had reasoned in uniformitarian terms, but it was Hutton who and his followers at Edinburgh, though vehemently attacked for decades, who introduced the necessary concept that "the present is the key to the past", into the mainstreams of geologic thinking",* (Mears, 1978)

The Nineteenth century C.E. saw further development in the geological mapping of Britain and Europe, and the subdivision of the stratigraphic record. Charles Darwin (1809-1882) Theory of Evolution gained scientific acceptance in the West with its application to the history of life on Earth. In the middle of that century, direct drilling into the subsurface strata in USA discovered oil in 1857. The developments in the search for oil enhanced the development of stratigraphic principles and many other aspects of geologic thinking to the present time.

The debate on geological concepts and theories is a continuous process, which is being carried out even during the last Twentieth century C.E. The latest plate tectonic theory brought many pro and against scientists to it, as also between the creationists and the evolutionists.

## Synthesis

In the discussion of Avicenna's contribution to the development of Earth Sciences, we must answer the previously outlined points:

1. Avicenna's contribution in Kitab Al-Shifa fills the gap in the history of Geology by bridging the Pre-Christian natural sciences with that of the Renaissance. It proves also, that mankind had already known a great deal of the nature of the Earth, many centuries than it was known in Europe.
2. There is no argument in the suggestion that Avicenna’s work is attributed to the Greek. If this argument is true, then modern Geology was born at the Greek time, not in the Renaissance of Europe, which is untrue.
3. The fundamental principles of Geology, such as the law of superposition of strata and uniformity in geologic processes were the products of Avicenna's time in the Eleventh centuries C.E.

Avicenna's methodology of field observation was original in Earth Sciences. The field observation constitutes an essential part in any geological investigation, especially in an area, which was never studied before. Avicenna's method of reasoning his field observations to reach an interpretation is another original method. He clearly distinguished between the processes of erosion, transportation, deposition, uplift and unconformities (the time separation between layers). Furthermore, he recognised the sequence of those events in long span of time, which stretches beyond human lifetime, to form mountains.

In other parts of Kitab Al-Shifa, Avicenna went beyond mountains and rocks, he wrote on meteorology, water salinity and other aspects of the earth, particularly the concept of formation and disintegration or decomposition. His ideas, taken collectively, constitute a natural philosophy of the Earth such as that constituted by James Hutton later in the Eighteenth century C.E. Hutton’s Theory of the Earth had basically called for the recognition of the fact that earth processes are continuous on Earth. This lead to the doctrine of uniformitarianism or the Present is the Key to the Past.

Recent studies by Porter (1977) on the History of Earth Science in Britain raised some points on the nature of Hutton's Theory of the Earth as being alien to the traditional school of thinking in Britain. The nature of that theory as being formulated from certain concepts before it was applied in the field. It was also alien due to the belief, that is being brought by it's founder who spent sometime studying Medicine and Law in Leiden in Holland and Paris in France, which housed large volumes of Islamic manuscripts before the Fifteenth century C.E. It is not intended here to prove or disprove how much Hutton was influenced by Avicenna's thinking? But to any researcher in the field of History of Science could see the impact of Avicenna's work in Medicine, Philosophy and Natural Sciences in the West.

To conclude this discussion, it is appropriate to quote again Toulmin and Goodfield (1965) on the Discovery of Time:

> *"For the time being (Avicenna's time), these insights were not followed up, and the full antiquity of the world remained unsuspected".*

Finally, it is suggested that certain effort should be made towards the publication of all parts of Avicenna's Kitab AI-Shifa, in a modern form together with elaboration on it's value in the influence of philosophy and natural sciences in Europe. Supplementing this effort by visiting Avicenna's field studied areas in the mountains around Amur Darya River in Afghanistan, Turkmenistan and Uzbakistan so that it's real antiquity could be appreciated.

**Figures and References to follow.**


**Figure 1: Location Map of Central Asia, after http://www.eia.doe.gov/emeu/cabs/uzbek.html**

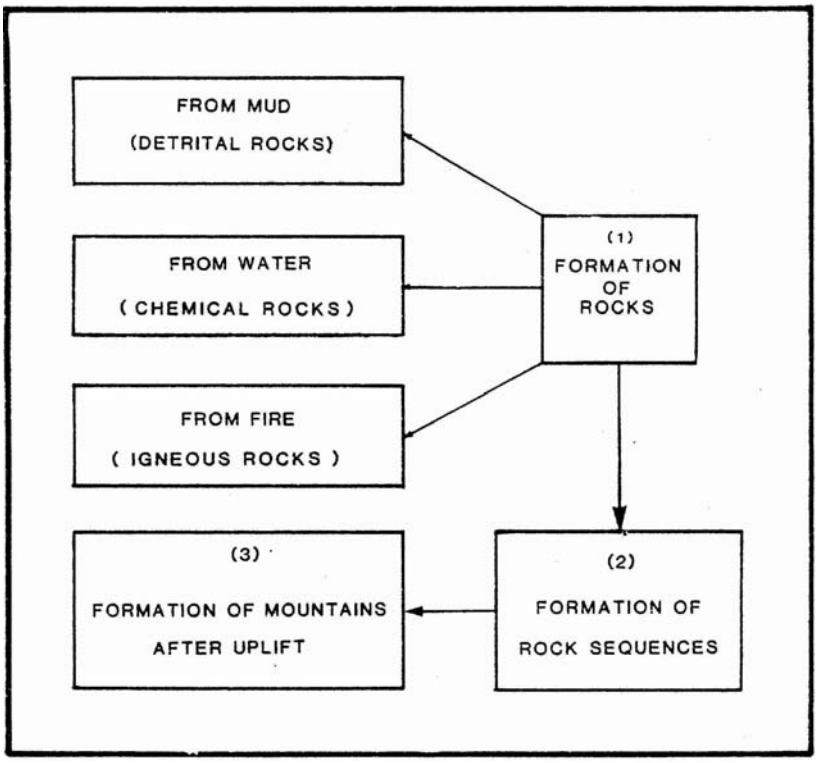


**Figure 2: Illustration of Avicenna's Sequence of Events to the Formation of Mountains, after Al-Rawi, 1983c.**

## SELECTED REFERENCES

1. Adams, F. D., 1938. The birth and development of geological sciences. First published by Williams & Wilkins Co., Baltimore. 506 P. Reprinted in paper pack by Dover Publication, New York, 1954.
2. Aldo Mieli, 1962. Arab Science and its importance in the development of world science. Translated to Arabic by Al-Naggar, A.H. and M.Y. Mosa, and edited by Fawzi, H. from the original French text. Dar Al-Qalam, Cairo, Egypt.
3. Al-Rawi, M. M., 1977. A concise account on the history of Arabic Earth Sciences. In: Proceedings of the First Symposium for the History of Arabic Science, University of Aleppo, Syria. First Volume in Arabic, p. 187-209, with abstract in English.
4. Al-Rawi, M. M, 1979. A comparative study between "Al-Ma'adin Wal Athar AI-Ulwiyah" of Avicenna (Ibn Sina) and the principles of modern geology". Paper presented in Arabic to the Second International Symposium for the History of Arabic Science, April 1979, University of Aleppo, Syria, 27 p. with abstract in English.
5. Al-Rawi, M. M., 1983a. The contribution of Ibn Sina (Avicenna) to the development of earth sciences in Europe. Paper presented to the conference on the Impact of Arab and Islamic Civilisation, December 1983, Oxford University, England.
6. Al-Rawi, M. M., 1983b. The concept of hydrologic cycle and underground water in the Arabian science and its impact on agricultural development. Paper presented in Arabic to the Third International Symposium for the History of Arabian Science, Dec. 1983. Kuwait, 14 p. with abstract in English.
7. Al-Rawi, M. M., 1983c. The contribution of Ibn Sina (Avicenna) to the Development of Earth Science in Europe. Proceedings of the Oxford University Conference on the Influence of the Arab and Islamic Civilisation. St. Anthony's College, Oxford, England, December 17-18, 1983.
8. Al-Rawi, M. M., 1984. Principles of Geology in "Al-Ma'adin Wal Athar Al-Ulwiyah" of Ibn Sina. (In Arabic). Journal of the Institute of Arabian Manuscripts. Kuwait. Vol. 28, Part 2, p. 547-564.
9. Al-Rawi, M. M., 1988. Geology and Mineralogy. Chapter 2, in Volume 4: Science in Islam. UNESCO, Paris, France, MS 31 P. Currently 2002 under publication by UNESCO, see www.unesco.org/culture/aic/index/html
10. Al-Shahat, A. A., 1968. Abu'l Rayhan Al-Biruni: life, publications and scientific research. Dar Al-Ma'arif, Cairo, Egypt. (In Arabic).
11. Al-Sukari, A. A., 1973. The Arabs and Geology. El Maaref Establishment, Alexandria, Egypt, 108 p. with 15 p. (In Arabic with summary in English).
12. Al-Ward, A. A. and I. J. AL-Fadhl., 1977. The Arab origin of earth science (Geology). In: Proceedings of the First International Symposium for the History of Arabian Science. University of Aleppo, Syria. First Volume in Arabic, p. 347-387.
13. Conant, J. B., 1963. History of Science. Translated and edited to Arabic by Zaki, A. Dar Al-Ma'arif, Cairo, Egypt.
14. Dennis, J. C., 1972. Structural Geology, 1. Historical Survey, P.9. The Ronald Press Co., N.Y.
15. Dean, D. R., 1979. The word "Geology". Annals of Science, Vol. 36, No. 1, p. 35 - 43.
16. Eicher, D. L., 1976. Geologic time. 2nd edition. Prentice – Hall International, Inc., London. 150 p.
17. Ferroukh, 0., 1970. The History of Arabian Science. Dar Al-Ilm, Beirut, Lebanon. (In Arabic).
18. Gould, S. J., 1967. Is Uniformitarianism Useful? Journal of Geological Education, Vol. 15, p. 149-150.
19. Hubbert, K. 1967. Critique of the Principle of Uniformity. In: Uniformity and Simplicity (GSA Special Paper 89) edited by C. C. ALBRETTON, Jr., p. 3-33, The Geological Society of America.

20. Ibrahim, M. M., 1957. I'ajaz Al-Quran Fi IlmT'abaqat Al-Ardh (The un-challengeable Quran in the science of earth's stratigraphy). Kostathomas & Co. Printers, Cairo, Egypt.
21. Ikhwan Al-Safa, 1957. "Rasa'l Ikhwan Al-Safa". Volume 2 on Natural Objects. Beirut and Sadr Publishing Houses, Beirut, Lebanon. (In Arabic).
22. Kennedy, E. S. et al, 1983. Studies in the Islamic Exact Sciences. American University of Beirut, Lebanon, 771 p.
23. Kennedy, E. S., 1970. Al-Biruni (or Beruni). Abu Rayhan (or Abul Rayhan) Muhammad ibn Ahmad. Directory of Scientific Biography, Vol. 2, p. 148-158, New York. Reprinted in KENNEDY, E. S. et al above p. 562-572.
24. Kummel, B., 1973. History of the Earth. An Introduction to Historical Geology, 2nd Edition. W.H. Freeman of Co., San Francisco, USA
25. Mears, B. Jr., 1978. Essentials of Geology. D. Van Nostrand Co., New York.
26. Montasir, A. H., et al, (Editors), 1965. "Al-Shifa" of Ibn Sina. Natural Sciences, Part 5 on Minerals and Meteorology. Amiri Publication, Cairo, Egypt. 94 p. (In Arabic with summary in French).
27. Morani, H. and Montasir, A. H., 1974. Readings in the History of Arabic Sciences. University of Mousil, Iraq. (In Arabic).
28. Nasr, S. H., 1976. Islamic Science. World of Islam Festival Publishing Co. Ltd, England, 273 p.
29. Potter, R., 1977. The Making of Geology. Earth Science in Britain 1660-1815. Cambridge University Press, Cambridge. 288 p.
30. Qassim, M., (Editor), 1969. "Al-Shifa" of Ibn Sina, Natural Sciences, Part 2 on Earth and Heavens, Part 3 on Formation and Decomposition, and part 4 on Actions and Reactions. Arab Book Publishing House. Cairo, Egypt. (In Arabic).
31. Sabra, A.H., 1976. The Scientific Enterprise. In: Lewis, B., (Editor). The World of Islam. Thames and Hudson, London, P.181-200.
32. Seyfert, C.K. and L.A. SIRKIN, 1979. Earth history and plate tectonics. 2nd edition. Harper & Row Publishers, New York.
33. Shell International Petroleum Co., 1966. The Petroleum Handbook. 5th Edition. Shell Centre, London SE1, 318 p.
34. Sokolov, V., 1972. Petroleum. Translated from the Russian by V. Purto. Mir Publishers, Moscow, 335 p.
35. SPEIZER, E.A., 1951. Ancient Mesopotamia: A Light That Did Not Fail. The National Geographical Magazine, Vol. XCIX, No. 1, p. 41-105.
36. Steno, N., 1669. An Early Statement of Ordering Principles in Earth History. University of Michigan, Humanistic Studies, Vol. XI, part 2, p. 229-230.
37. Toulmin, S. and Goodfield, 1965. The Ancestry of Science: The Discovery of Time. Hutchinson & Co. (Publishers) Ltd., London.
38. Whitehead, A.N., 1925. The origins of modern Science. In: Science and the Modern World, The Macmillan Co., renewed 1953 by E. WHITEHEAD.
39. Wickens, G. M., 1976. The Middle East as a World Centre of Science and Medicine. In: Savory, R.M. (Editor), Introduction to Islamic Civilisation, Chapter 10, P.111-119. Cambridge University Press, Cambridge.
40. Zahoor, A., 2002. Abu Ali Al-Hussain Ibn Abdallah Ibn Sina (Avicenna). In: http://users.erols.com/zenithco/sina.html
41. Zahoor, A., and Haq, Z., 2002. Quotations from famous historians of Science. In: http://users.erols.com/zenithco/sina.html (Copyright 1990, 1996, 1997 All Rights Reserved).