SHORTER COMMUNICATIONS

PETROGENESIS OF THE SIWALIK SEDIMENTS OF NORTH-WESTERN HIMALAYAS

R. S. CHAUDHRI
Centre of Advanced Study in Geology, Panjab University, Chandigarh

Introduction: Although Siwalik formations have attracted the notice of palaeontologists for more than a century, yet very little attention seems to have been paid towards the petrogenetic aspect of the sediments. In order to work out the provenance and environments of sedimentation, about 400 rock specimens representing various lithological units of the entire Siwalik sequence from different sections of the north-western Himalayas were subjected to detailed petrological, sedimentological and mineralogical investigations.

The Siwalik sequence constituting the Kamlial, Chinji (Lower Siwalik); Nagri, Dhokpathan (Middle Siwalik); Tatrot, Pinjor and Boulder Conglomerate (Upper Siwalik) ranging in age from Helvetian to Cromerian (Krishnan, 1968) attains a thickness of 5,000-6,000 m in this region.

Observations: In order to maintain brevity of the paper, only the more significant points having a bearing on the petrogenesis of the Siwalik sediments are recorded herein.

Different petrological rock types met with in the Lower Siwaliks include protoquartzites, lithic greywackes, lithic subgreywackes, ferruginous sandstones, siltstones/clays besides thin intercalations of intraformational conglomerates, and are the same as observed in the Dagshai-Kasauli sequence (Chaudhri, 1970). The detritus falls in the angular to subangular grade and is poorly sorted. Association of detrital grains of heterogeneous sizes and shapes is a common feature. The rock fragments constitute a high proportion (30-35%) of the modal composition and represent sandstones, siltstones, limestones, various types of schists and gneisses. Cement in general is mechanical matrix (20-30%) but carbonate and iron oxide have also been recorded to constitute 15-20% and 10-15% of the lithological composition respectively. Along the contact of quartz and calcareous cement, development of reaction rims is frequently observed. Quartz shows undulatory as well as non-undulatory extinction and bears inclusions of various minerals. The rocks, in general, are felspar poor. More important amongst minor mineralogical components are zircon, tourmaline, rutile, garnet, chlorite, chloritoid, staurolite, epidote, muscovite, biotite and opaque minerals.

Lithic greywackes, lithic subgreywackes, ferruginous sandstones and siltstones/clays constitute major petrological units of the Middle Siwaliks. While the angularity of the detrital grains, poor sorting and association of heterogeneous sizes and shapes continue to be the same as for the Lower Siwaliks, the rock fragments constitute a little higher proportion (30-40%) and represent more varied types of schists. Mechanical matrix also shows a significant increase and the same holds true for the chemical precipitates. Presence of prismatic euhedral grains of quartz with terminated pyramidal faces is a conspicuous feature. Percentage of polycrystalline quartz also registers an appreciable increase. Frequency of reaction rims between quartz and calcareous matter is more or less the same. The rocks are felspar poor and show an increase in mica content. Various minerals encountered in the Lower Siwalik sediments are met within the Middle Siwaliks as well. Addition of kyanite is rather significant.

Amongst the more important petrological units met within the Upper Siwaliks are conglomerates, lithic greywackes, lithic subgreywackes and siltstones/sandy clays. Conglomerates represent boulder to granule sized fragments of various shades of quartzites, sandstones, siltstones/clays, limestones and various types of schists and gneisses. In the sandstones, rock fragments at times exceed 50% of the rock composition; while in general they represent the rock types mentioned above, addition of fragments of basalt in the suite is a significant point to note. Clay matrix constitutes 20-30% of the rock composition. Polycrystalline quartz continues to dominate. There is an appreciable increase in the number and variety of minor mineralogical components, the most important addition being sillimanite.

Discussion: Although there is a general agreement in so far as the northern direction of the source rocks is concerned, yet views regarding the nature of source rocks have remained divided and all the petrological types from crystalline schists and granitic rocks, granites from the core of Central Himalayan region to sedimentary rocks have been suggested.

Detailed field and laboratory investigations reveal beyond doubt that there exists hardly any difference between the Dagshai-Kasauli sequence of the Lower Tertiaries and the Lower Siwaliks (Nahans), and as such detritus of the latter must have been derived from the same source rocks and got deposited under identical environmental conditions. Acid plutonic rocks, low and medium grade metamorphics and sedimentary rocks of the adjacent Himalayan region served as source rocks for the Lower Tertiary sediments (Chaudhri, 1969).

Most of the sediments constituting the Middle and Upper Siwaliks have been derived from medium and high grade metamorphics as is evinced by the large proportion of fragments of various types of schists and gneisses, higher mica content and presence of an assemblage of high grade metamorphic minerals. The high proportion of polycrystalline quartz in Middle and Upper Siwaliks also indicates primary and/or metamorphic rocks. Blatt and Christie (1963) suggested the primary nature of source rocks of polycrystalline quartz while Bokman (1952) and Blatt (1967) attributed the source of polycrystalline quartz to metamorphic rocks. The higher proportion of polycrystalline quartz, however, may be due to coarser size of the detritus as well (Conolly, 1965). Primary and metamorphic source rocks are also suggested by the greater variety of mineral species present in the Middle and Upper Siwaliks.

Thus, the Himalayan rocks supplied sediments for the Lower Tertiary formations and the Siwaliks. It is rather logical to expect that after the removal of sedimentary veneer and a thick cover of low and medium grade metamorphics, the crystallines and deep seated metamorphics were exposed to denudation during the Middle and Upper Siwalik sedimentation and supplied detritus to them (Chaudhri, 1969, 1970; Sinha, 1970).

Presence of fragments of sandstones, siltstones and shales are an indication of contribution of the detritus by clastic rocks. Fragments of limestones and significant proportion of calcareous cement indicate the presence of carbonate rocks in the source area.

Presence of fragments of basalt in the Upper Siwaliks is suggestive of emergence of traps (basalt) as source rocks during the Upper Siwalik time. The basin in which the thick deposits of Siwaliks accummulated has been variously termed as 'Indo-brahm', 'Faulted geosyncline' 'Siwalik river' 'Middle Tertiary river' 'Foreland', 'Local intermittent basin' and 'Foredeep'. Lower Siwaliks are said to have been deposited in 'extensive basin', (Raiverman, 1968) and in 'geosyncline' (Saxena, *et al.*, 1968). It has been proposed in general that the sediments were deposited in flood plain environments (Krynine, 1937). Lacustrine nature of the Siwalik detritus has also been advocated by Krishnan, Raiverman and many others.

It is needless to discuss the terminology used to name the basin of deposition and to increase the confusion by adding yet another term; suffice it to say that there existed a basin occupying roughly the present seat of the Siwalik belt, transverse to the main Himalayan drainage. The Himalayan rivers and their tributaries heavily laden with sand, silt and coarser components discharged the rock waste into this basin. Factors such as high proportion of undecomposed rock fragments, angular to subangular nature of the detritus, poor sorting and presence of fossil vegetable matter are a sure indication of the closeness of the source rocks and basin of deposition.

In the Middle and Upper Siwaliks such features as current bedding, ripple marks, presence of logs of fossil wood, association of cobble and pebble sized fragments with sand grade detritus and poor sorting are suggestive of shallow water nature of the deposits. Dominance of one lithology and presence of slumps in current bedded rocks are also indicative of shallow water nature (Packham, 1954). Development of reaction rims at the junction of quartz and carbonate cement is suggestive of rapid burial (Siever, 1959).

Huge thickness of the Middle and Upper Siwaliks (3,500 m approx.) with all the shallow water characteristics, and conclusive evidences of rapid burial suggest beyond doubt a fast sinking shallow basin.

Climatic conditions varying from present day environmental conditions sub-tropical with medium rainfall, subtropical and eolian, subtropical, tropical humid, arid to temperate and moderately humid to monsoon have been suggested for the Siwalik sedimentation. Without making speculative remarks regarding the climatic conditions, the present investigations suggest an environment in which rapid erosion was possible. Frequency of fossil vegetable matter is suggestive of a warm, humid climate with moderate rainfall. This contention is reinforced by the rich fossil vertebrate fauna entombed in the Siwaliks.

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GEOCHEMISTRY OF SPHALERITE FROM INGALDHAL MINE CHITRADURGA DISTRICT, MYSORE STATE

K. V. S. ACHARYULU AND C. BORRESWARA RAO
Department of Geology, Andhra University, Waltair

Introduction: The Ingaldhal sulphide mine is situated about 8 km SE of Chitradurga in Mysore State. Mineragraphic and minor element studies reveal that the ore mineral assemblage, occurring mainly in schisted chloritic rocks (meta volcanics), represents a typical hydrothermal deposit. The purpose of this paper is to present quantitative estimates and discuss the distribution of Fe, Mn and Cd, the most important elements that substitute for Zn in sphalerite (Zns). Eleven core samples from seven bore holes have been selected for analysis such that 5 of them represent the vertical variation in the minor element concentration, if any, and the other the lateral variation.

Analytical method: The selected sphalerite samples were analysed for zinc, sulphur, iron, manganese and cadmium by electron probe micro-analysis. Under the analytical conditions employed, detection limits were 0.01% Fe and Mn and 0.008% Cd. In each of the samples 12 to 16 grains were probed at random choosing inclusion-free areas and the average estimates, are listed in Table I.

The distribution and correlation of minor elements are given below:

Manganese: There is a general agreement that the manganese content of sphalcrite varies with iron content and that it is highest in samples from high temperature deposits. The results of Kullerud (1953) agree with this in general but with many exceptions. Rose (1967) found no correlation between Mn and Fe for the samples from Bingham district. In fact, he observed highest manganese concentrations in sphalerite of very low iron content. Hughes (unpublished) considers the Mn content to be both temperature and pH dependent.

Mn is found in all the analysed sphalerite samples from Ingaldhal mine and ranges between 0.01 wt.% and 0.074 wt.%, The data (sample Nos: 7C/102 to 7C/582 given in Table I) show increases and decreases in the Mn content with depth. The Mn values are plotted against the corresponding Fe values and no systematic variation is observed (Fig. 1).