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Engineering Geological Understanding and Its Implications in Mines and Quarries: A Case Study of Khairabad Limestone

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1. Preliminary information on the area

The quarry industry has advanced due to the vast requirements of construction materials like crushed stones and aggregate and its importance in international industrial and economic improvement. Limestone is a rock unit that is widely used in Pakistan for engineering projects and cement production because it is known for its great strength, geochemical oxide compatibility, and durability. The current study emphasizes (i) accessing the engineering geological understanding of newly discovered mines and quarries of Limestone in the Khairabad section, (ii) checking the suitability for concrete/road engineering works and for use in the cement industry mainly for which is being quarried in the Khairabad area in the vicinity of Maple Leaf Cement Factory, Punjab Pakistan. The Khairabad Limestone quarries are located in the East of the Kalabagh fault, roughly at a latitude of 71° 38′ 15″ and a longitude of 32° 52′ 30″ with an elevation of 690 ft (210 m) (Figure 1). Limestone is widely uncovered and well exposed in Khairabad village, near Kalabagh, Mianwali. The limestone is light to medium gray, medium bedded, hard, and nodular. The study consists of the collection of samples, reconnaissance surveys, and identified major limestone deposits for the development of a new quarry. Different samples were collected based on the lithological variations. The literature review reveals that the Salt range remains a point of interest for national and international researchers. However, some national scientists put their best effort into assessing the aggregate assets of the Salt Range to analyze their suitability for economic quarry construction missions. Previous studies indicate that many researchers have been using the aggregate and its geo-mechanical properties together to meet the specification requirements for limestone aggregates in various applications (Al-Ansaray and Iyengar, 2013; Naeem et al., 2014)

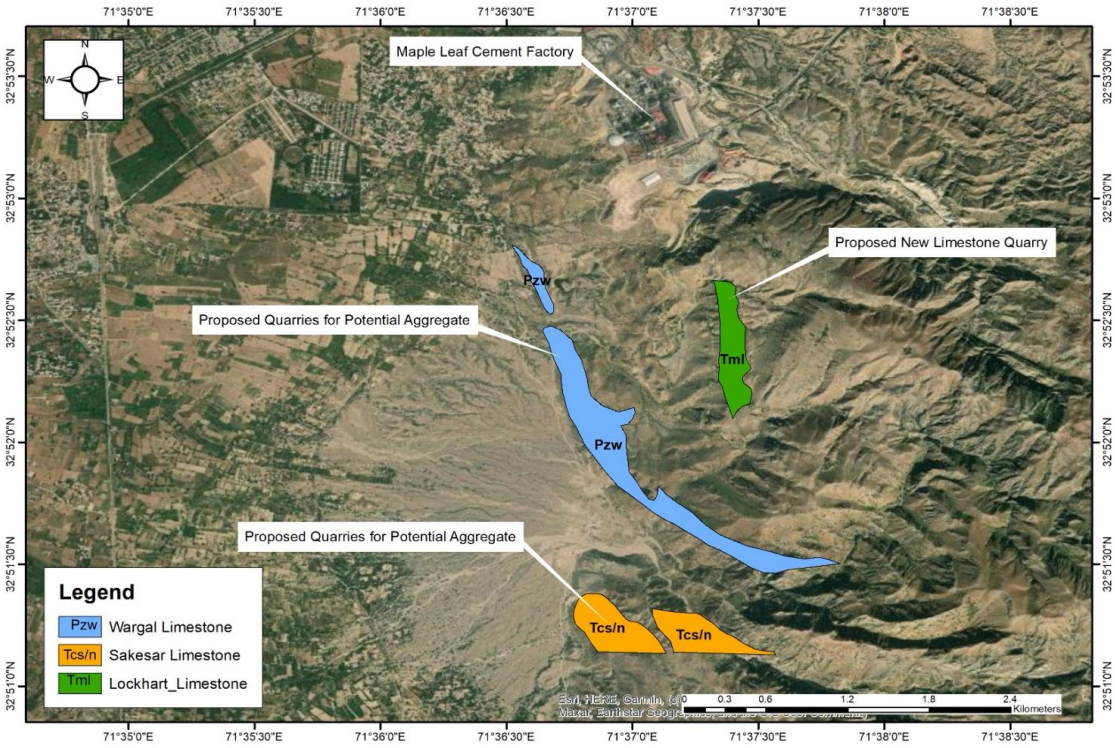

Figure 1. The map showing the locations of outcrops of Limestone quarries in the Khairabad section (Source Google Earth Image 2024, using ArcGIS).

2. Role of Engineering Geology

This article introduces engineering geological applications in quarries and mines and takes attention to the role of engineering geology in the extraction phase of construction materials (aggregates) and different industrial minerals from quarries and mines. The discussion also describes three different characteristics of the design and operation of quarries. First, the safe, well-planned useful extraction of minerals from the available mining land area with minimum environmental issues. In addition, engineering geological ground models are compulsory to develop the design of the quarry's life span from initial excavation to closure and final rehabilitation. Second, environmental changes which may be permanent or temporary occur in the area surrounding the quarry as a result of mineral extraction. Third, to understand the ground conditions throughout a quarry's life span, several additional factors need to be addressed in the planning and management of the quarry. These include the quality and quantity of retrievable material and the suitability of the recovered and processed material for its intended use (Allington et al., 2023). Moreover, in the development of mines and quarries, the role of engineering geology is vital because these studies provide primary information about the area and precept into the geological conditions of the site.

In this context, this short article focuses on proposing new limestone quarries in Khairabad village (Mianwali) and addressing the significant need for earthworks (such as aggregates and building stones) and the cement industry. To evaluate this study, basic laboratory testing and field research were conducted in collaboration with a professional geologist team from the Department of Earth Sciences at the University of Sargodha. The physical properties of the limestone were assessed, with the following results: Los Angeles Aggregate Abrasion Value (26.59%), Aggregate Crushing Value (12.84%), Aggregate Impact Value (13.91%), and Specific Gravity (2.69%). These values indicate that this deposit is a potential source for the aggregate industry in the Western Salt Range. The study clearly shows that all engineering geological considerations for Khairabad limestone reveal it to be a feasible and promising source of aggregate material in the region.

The study also evaluates the suitability of limestone as a raw material for cement production. To assess its geochemical suitability, a variety of samples were analyzed using XRF and XRD techniques. The results indicate that the chemical composition of the limestone is appropriate for cement production. Specifically, the major components are; CaO at 52%, MgO at less than 1%, SiO_2 ranging from 1% to 1.5%, Alkalis with K_2O at 0.06% and Na_2O at 0.15%, SO_3 ranging from 0.04% to 0.1%, and Chloride at 0.011% to 0.015%. These results provide valuable information for evaluating cement chemistry.

3. Concluding Remarks

The engineering, physical, and geochemical/mineralogical characteristics of source materials (crushed rocks and natural sediments) are used for quality assessment of aggregates and industrial purposes. Engineering geology applies engineering principles to optimize operations, mitigate risks, and address environmental concerns in mines and quarries, promoting sustainable development. Effective quarry planning ensures the safe, productive, and profitable extraction of usable materials, along with favorable final rehabilitation and land usage that gains public approval. The limestone deposits in the Khairabad section are a valuable source of aggregate for the cement industry and building stones. Future research should include detailed petrographic studies and additional material testing to aid in the design of aggregate and concrete work.

Acknowledgments

The works listed above in the study area have been studied with the geologist team of the University of Sargodha, Department of Earth Sciences, and reviewed using the published literature cited in the text.

References

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