Geology, Petrography, and Mineralization of Sedimentary Hosted Strata-Bounded Barite Deposit at Gunga, Khuzdar District Balochistan, Pakistan

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Abstract: Gunga deposit is a type of sedimentary exhalative (SEDEX) deposit located in the northwest of Khuzdar Knot within the Kirthar Fold Belt (KFB) in the south-west of Khuzdar city. This deposit is formed during the late Triassic-Jurassic period due to rifting of the Gondwana supercontinent. being hosted with the Anjira Member of Jurassic Shirinab Formation, hosted the Strata bounded barite mineralization in these deposits contact with the siliceous and iron-rich gossan zones. The Baritic zone indicates the complex replacement of silica with the continuous silicification which is followed by massive to brecciated type Barite. Petrographically, barite has a very fine to coarse grain texture, anhedral to euhedral crystal shape, and forms dendritic crystal structure In the Back Scattered Electron (BSE) images, the crystal morphology of Barite exhibits well-developed elongated crystal structures with medium to coarse grain texture. Energy Dispersive X-rays (EDX) graphs indicates the high peaks of Ba, S, and O elements associated with sub-peaks rock-forming mineral elements (Si, Al, Na, K, and Ca) along with sub-peaks of ore-forming mineral elements (Pb, Zn, Fe, P, and Ni).

Keywords: Gunga, Khuzdar, Kirthar fold belt, SEDEX mineralization, barite.

Introduction

The word SEDEX stands for the sedimentary exhalative, formation of laminated sulphides ore in the non-clastic chemical sediments, carbonaceous shale, and very fine clastic rocks (Carne and Cathro, 1982, Cook et al., 2000; Sawkins, 2013; Wilkinson, 2013). These deposits are formed by the precipitation of hydrothermal solution that has been exhaled on the seafloor (Leach et al., 2005b; Leach et al., 2010; Wilkinson, 2013). Tectonically, SEDEX deposits are related to extensional or rift-related tectonic environments within the sedimentary basin, i.e., an epicratonic, inter-cratonic region, distal back arc, and passive continental margins (Lydon, 1995; Leach et al., 2005b; Lydon and Goodfellow, 2007). Some authors favours that the SEDEX deposits are formed by the saline basinal brines and an important source of sulphides ore from the high constituents of ore fluids formed by the hydrothermal system (Hutchinson, 1980; Badham, 1981; Russell et al., 1981; Lydon, 1983, 1986; Sawkins, 1984; Goodfellow et al., 1993; Garven et al., 2001; Leach et al., 2004; Yang et al., 2004; Large et al., 2005). Structurally, the SEDEX deposits are controlled by the normal fault in the intracratonic and epicontinental basin, and structures like host and graben are associated with the first order basin, second-order basin, and third-order basin (Emsbo et al., 2016; Jaing et al., 2020; Morris, 2020).

In this paper we discuss the geology, petrology, and mineral characteristics of Sedimentary Hosted Strata-Bounded Barite in Gunga deposit of south-west part in Khuzdar of Kirthar Belt in southern, Pakistan. The findings of this research help to understand the field relation, petrological and mineralization characteristics of Barite in the sedimentary hosted Gunga deposit.

Geological Setting

Gunga deposit is located southwest of the Khuzdar city, in Kirthar Fold and Thrust Belt (KFTB). The KFTB is a major tectonic belt of East Balochistan Fold and Thrust belt and extends about 380 km long and 50 to 70 km wide zone (Kazmi and Jan, 1997). This Fold and Thrust Belt is bounded by the Chaman - Nal-Ornach Transform Fault system and Bela Ophiolite in the east and Lower Indus Basin in the west (Bander and Raza, 1995) (Fig.1). Structurally KFTB divides into several sub-structural units i.e., Kalat Anticlinorium, Kalat Plateau, Khuzdar Knot, Khude Range fold belt, and Karachi embayment zone (Kazmi and Jan, 1997). Two major tectonic events controlled the geology of Khuzdar and its surrounding The first event occurred during the Late Triassic-Jurassic period, the rifting and extensional of Gondwanaland (Powell, 1979; Ahsan, 1995; Lydon, 1989). The sedimentary strata hosted the ore minerals deposited in response of rifting (Ahsan, 1995), the transition of vertical facies in the Firozabad group (Jurassic). The Firozabad group shows a transgressive
continental shelf environment, progradation of the platform shelf, proximal clastic, and slope carbonate environments (Ahsan and Mallick, 1999). During Late Cretaceous to Early Tertiary Period, the second tectonic event occurred when the Indian continental plate separated from the Arabian Plate. The final collision of Indian Plate with the Eurasian Plate developed the Kirthar-Sulaiman Fold and Thrust Belt. During this collision of two major plates the ophiolites (Bela-Khuzdar ophiolite, Muslim Bagh-Zhob ophiolite, and Waziristan-Khost Ophiolitic complexes) obducted on the northwest boundary of Indian plate (Powell, 1979; Ahsan and Mallick, 1999).

Mineralization of barite deposits in the Gunga is strata-bound within the Jurassic Anjira Member mainly composed of limestone and shale in the middle part of Shirinab Formation (Husain et al., 2002). This succession is widely exposed in the KFTB (Fatmi et al., 1986; Siddiqui and Sharp, 1993; Hussain et al., 2002; Khan and Clyde, 2013). Stratigraphically, the study area is composed of Jurassic to Cretaceous sedimentary successions. Shirinab Formation is mainly composed of limestone and shale where the lower part of the Formation is transitionally in contact with the Late Triassic Wulgai Formation and the upper part is conformably overlain with Loralei Member (Kazmi and Jan 1997). According to Williams (1959) Spingwar Member is enriched ammonite’s species and based on these ammonite fossils the member presents an early Jurassic (Kazmi and Jan 1997). Loralei Member is mainly composed of medium to thick-bedded limestone. The lower part of the Loralei Member conformably contacts with the Spingwar Member and transitional contact with the Anjira Member Kazmi and Jan (1997) assigned Early Jurassic age for the Loralei Member. The Anjira Member comprises of medium bedded argillaceous limestone interbedded with the mudstone. The upper part of the member is in disconformable contact with the early Cretaceous Sembar and Goru Formations (HSC, 1960; Fatmi, 1986; Kazmi and Jan 1997). This Member presents early to middle Jurassic age based on ammonite fossils (Kazmi and Jan 1997).

**Local Geology**

The Gunga deposit is located 11 km southwest of Khuzdar city in Balochistan province, covered an area of 1500 Km² (Fig.1). The Gunga deposit gives rise to an especially complex geological structure that has been intensely affected by the complex tectonic structures of Khuzdar Knot (Bander and Raza, 1995; Kazmi and Jan 1997) (Fig.1). The Anjira and Loralei Members of the Jurassic Shirinab Formation host the mineralization zones of barite in the study area, which divided in to various sub-units (Fig.1 and 2).

![Fig. 1: Geology and Tectonic map of Kirthar Fold and Thrust Belt (KFTB) (Kazmi and Jan, 1997).](image1)

![Fig. 2: Geological map of the Gunga deposit area.](image2)
The Loralai Member is subdivided into four different units (a) Lower Loralai Limestone and Shale Unit, (b) Lower Loralai Limestone Unit, (c) Middle Loralai Unit, and (d) Upper Loralai Unit. Lower Loralai Limestone and Shale Unit of Loralai member bounded by 10 to 15m thick bed of limestone with interbedded shale, while the total thickness of this unit is about 50 m. The Lower Loralai Limestone unit consists of a 2 to 5 m thick bed of limestone interbedded with grey shale and brownish micritic limestone and it total thickness is 20 to 100 m. Middle Loralai unit composed of 10-20cm thick-bedded of mottled grey fossiliferous limestone with interbedded brownish weathering limestone. This unit is associated with limonitic stained beds in the lower part of the unit. The total thickness of the Middle Loralai unit is 200 to 250m. The Upper Loralai unit is marked as the top unit of the Gunga deposit and is bounded by a thick bed of shale and highly fossiliferous limestone. This unit is associated with the upper part of the Loralai unit. The total thickness of the Upper Anjira Unit is about 30 to 75m thick (Fig.3).

Gossans in Study area

Gossan is highly oxidized zone, generally expose on the surface or upper part of the ore deposit (Gilbert and Park, 1986). At the Gunga deposit, the gossan zone is exposed at the surface of the ore body. Based on their chemistry two types of Gossan zones are identified. i.e., Siliceous Gossan and Baritic Zone (Fig.4. a - b).

Siliceous Gossan

The siliceous gossan in the study area presents as ridge shape structure. The main ridge of siliceous gossan is characteristically black, purplish brown to rusty color veinlet infiltrated light grey altered rocks in stockwork and spheroidal pattern (Fig.4. c - d). The middle part of siliceous gossan is covered by dark ferruginous cover; a massive, widely extended gossan, in contact with the middle unit Anjira Member and barite mineralized zone. The siliceous gossan zone is underlying the mineralized zone, which is separated from a few meter-thick brownish interbedded shales with thin-bedded limestone in the southern part of the deposit (Fig. 2). In the northern part, the siliceous zone is very narrow because of the sequence of brecciated limestone-shale. The siliceous gossan zone is typically identified as an oxidation weathering zone that mainly consists of disseminated sulfides. This mineralized zone is enriched with lead and zinc sulfides (Fig.4. e).

Baritic Zone

The middle part of the Jurassic Anjira Member hosts barite mineralization (Fig.4 a & b). A complex replacement of silica where series of continuous silicification commonly occurs in the massive barite to brecciated barite. The brecciated barite has a low-density siliceous sinter matrix and completely siliceous breccia with replacements of silica in the barite clast. Beds of barite have been bleached cap by silicified shale in the northern dump area, the interlayered barites are separated by bleached shale (Fig.4. f - g). In the southern
part of the deposit area, 3 to 4m thick-bedded barite is overlain with sinter-like breccia. In the open pit mine, the massive bed of barite contacts with siliceous gossan zone, hematite and limonitic gossan, and Anjira Member (Fig.4. h - i).

**Material and Method**

A fifteen-day geological fieldwork has been carried out in and surroundings of the Gunga deposit. In this fieldwork we marked the gossan zones and a detailed field investigation of ore mineralized zones. The representative samples have been collected from both ore body and host rocks. The petrographic and textural characteristics of twenty selected samples were identified by Leica DM 500 binocular microscope in the Center of Excellence in Mineralogy (CEM), University of Balochistan, Quetta. The Scanning-Electron Microscopy (SEM) on five ore samples have been carried out on SEM-EDX (Model JSM 910) in CEM, University of Balochistan, Quetta.

**Results and Discussion**

**Petrography**

**Barite**

In thin sections the texture of barite varies from medium to coarse grain with fine grain groundmass. The coarse grain crystalline barite commonly exhibits radiating or prismatic subhedral to euhedral crystals shape occurs in a vein or vugs filling. The fine-grained anhedral barite is mainly abundant in the groundmass formed during hydrothermal alteration. Barite is mainly associated with fine-grained calcite, quartz, and clay minerals (Fig. 5 a - f).
**Scanning Electron Microscope-Electron Dispersive X-rays Spectroscopy (SEM-EDX) Technique**

**Barite (BaSO₄)**

Barite is the primary mineral of the sulfates group chiefly consisting of Ba, S, and O. In the BSE images the crystal morphology of barite and barite grains depicts well-developed elongated crystal structures with medium to coarse grain texture (Fig. 6. a - d).

The mineral maps from SEM-EDX analysis shows the major composition of barite associated with minor constituents of other minerals. EDX shoot point, spectra, and map represent the peaks of major elements of barite. In this analysis count the 500 to 1300 elements of Ba with 4.2 energy (KeV), count the 3500 elements of S with 2.15 energy (KeV), and count the 3000 elements of O with 0.5 energy (KeV). SEM-EDX analysis specifies high peaks of Ba, S, and O elements, the peak O element is high, and S and Ba elements are nearly equal. Along the high peaks of O, S, and Ba associated with the sub-peaks rock-forming mineral elements are including a Si, Al, Na, K, and Ca and sub-peak of ore forming mineral elements are including a Pb, Zn, Fe, P and Ni (Fig. 7 a - b). The minimum value of Ba is about 40.89, the maximum value of Ba is about 81.41% and the average value of Ba is about 51.31 % in the study area (Table 1).

The barite is a valuable economic mineral with a wide range of applications in the industry. The chief usage of barite (~85%) is in the petroleum industry for the drilling purpose and valuable for cement industry, paints, ceramics, manufacturing of glass, and in the chemical industry (Ene and Okogbue, 2012). According to, the total estimated reserves of barite in the Gunga deposit is ~1.28 million tons (Klinger and Ahmed, 1967). The Gunga deposit is mainly comprised of barite, the minimum percentage of Ba is 40.89%, the maximum percentage of Ba is 81.41 and the average percentage of Ba is about 51.31 %, (Table.3.1).

**Conclusion**

1. The barite mineralization in the Gunga deposit hosted within the middle Jurassic Anjira Member.
2. The mineralization is mainly associated with siliceous gossan zone.
3. Petrographically, barite displays very fine to coarse grains texture and anhedral to euhedral crystal shape with dendritic crystal structures.

**Table 1: Illustrate the results of SEM - EDX shoots point analysis for barite mineralization.**

| Sample No | Mineralized Zone | O% | Si % | C% | Ba% | Pb% | Zn% | Fe% | S% | Sr% | F% | S% |
|-----------|------------------|----|------|----|-----|-----|-----|-----|----|-----|----|----|
| BK-5-B    |                  | 29.50 | 1.16 | 4.42 | 46.37 | 7.49 | 0.13 | -   | 10.94 |
| BK-11-C   |                  | 60.23 | 24.99 | 14.77 | 55.25 | -   | -   | 10.33 |
| BK-15-B   |                  | 20.92 | -    | 3.99 | 47.98 | 8.18 | -   | -   | 9.93 |
| BK-20-B   |                  | 36.00 | -    | 4.42 | 40.89 | 21.69 | -   | -   | 10.77 |
| BK-22-C   |                  | 29.18 | 30.95 | -   | 46.54 | 10.26 | -   | -   | 11.34 |
| BK-23-A   |                  | 34.84 | 0.29 | 11.97 | 41.97 | -   | -   | 10.92 |
| BK-25-C   |                  | 7.43  | 0.83 | 4.21 | 81.41 | -   | -   | 4.68 |
| BK-25-D   |                  | 20.51 | 2.45 | 17.2 | 50.13 | 0.97 | -   | -   | 4.2  |
| Average   |                  | 30.95 | 10.11167 | 8.711429 | 51.3175 | 9.71 | 0.13 | -   | 9.1387 |

Fig. 6: Photomicrograph of BSE, SEM-EDX, and EDX map showing a crystal shape, texture, composition, and minerals grains of barite. BSE image represents the crystal morphology, crystal structures, and medium to coarse grain texture of barite (a - d).

Fig. 7: SEM-EDX and EDX minerals maps are showing the high peaks major constituents and mineral grains of Barite (a - b).
The high peaks of Ba, S, and O along with sub-peaks of major rock-forming mineral elements (Si, Al, Na, K and Ca) and ore-forming mineral elements (Pb, Zn, Fe, P, and Ni), thus the high peaks of Ba, S and O indicates that Gunga is a barite (BaSO₄) deposit.

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References

Ahsan, S. N. (1995). Petrogenesis of Shirinab Formation, Lasbela-Khuzdar area, Balochistan, Pakistan. Ph. D. dissertation, Dept. Geol., Univ. Karachi.

Ahsan, S. N. (1996). A genetic model for zinc-lead mineral deposits, Lasbela and Khuzdar Districts, Balochistan, Pakistan. Geologica, 2, 1-22.

Ahsan, S. N., and Mallick, K. A. (1999). Geology and genesis of barite deposits of Lasbela and Khuzdar Districts, Balochistan, Pakistan. Resource Geology, 49(2), 105-111.

Badham, J.P.N., (1981) Shale-hosted Pb-Zn deposits. Products of exhalation of formation waters: Applied Earth Science Transactions of the Institution of Mining and Metallurgy, Section B, v. 90, p. 70–76.

Carne, R.C., and Cathro, R.J., (1982). Sedimentary exhalative (SEDEX) zinc-lead-silver deposits, northern Canadian Cordillera: CIM Bulletin, v. 75, no. 840, p. 66–78.

Cooke, D. R., Bull, S. W., Large, R. R., and McGoldrick, P. J. (2000). The importance of oxidized brines for the formation of Australian Proterozoic stratiform sediment-hosted Pb-Zn (Sedex) deposits. Economic Geology, 95(1), 1-18.

Emsbo, P., Seal, R. R., Breit, G. N., Diehl, S. F., and Shah, A. K. (2016). Sedimentary exhalative (sedex) zinc-lead-silver deposit model (No. 2010-5070-N). US Geological Survey.

Ene, E. G., Okogbue, C. O., and Dim, C. I. P. (2012). Structural styles and economic potentials of some barite deposits in the Southern Benue Trough, Nigeria. Romanian Journal of Earth Sciences, 86 (1), 27-40.

Fatmi, A. N. (1977). Mesozoic. Stratigraphy of Pakistan, 12, 29-56.

Fatmi, A. N., Hyderi, I. H., Anwar, M., and Mengal, J. M. (1986). Stratigraphy of Zidi formation (Ferozabad group) and Parh group (Mona Jhal group) Khuzdar district, Baluchistan, Pakistan.

Garven, Grant, Bull, S.W., and Large, R.R., (2001). Hydrothermal fluid flow models of stratiform ore genesis in the McArthur Basin, Northern Territory, Australia: Geofluids, v. 1, no. 4, p. 289–311.

Gilbert, J.M., and Park, C.F., (1986). The Geology of Ore Deposits. Ed. Freeman and Company, New York (983 pp.).

Goodfellow, W.D., Lydon, J.W., and Turner, R.J.W., (1993). Geology and genesis of stratiform sediment-hosted (SEDEX) zinc-lead-silver sulphides deposits, in Kirkham, R.V., Sinclair, W.D., Thorpe, R.I., and Duke, J.M., eds., Mineral deposit modeling: Geological Association of Canada special paper 40, p. 201–251.

Goodfellow, W.D., and Lydon, J.W., (2007). Sedimentary exhalative (SEDEX) deposits, in Mineral deposits of Canada. A synthesis of major deposit types, district Metallogeny, the evolution of geological provinces, and exploration methods: Geological Survey of Canada, Mineral Deposits Division, Special Publication 5, p. 163–184.

Hunting Survey Corporation Limited (1960). Reconnaissance geology of part of West Pakistan. A Colombo Plan Cooperative Project, Government of Canada, Toronto, 550p.

Husain, V., Khan, H., Germann, K., and Zak, K. (2002). Geochemical investigations of strata bound Gunga barite deposits of Khuzdar (Balochistan), Pakistan. Resource Geology, 52(1), 49-58.

Hutchinson, R.W., (1980). Massive base metal sulphides deposits as guides to tectonic evolution, in Strangways, D.W., ed., The continental crust and its mineral deposits: Geological Association of Canada special paper 20, p. 659–684.

Jiang, S. Q., Xu, Y., Sun, S. X., Wang, C., and Li, L. (2020). Global distribution of Lead-Zinc Resources. Geology and Resources, 29(3), 224-232.
Kazmi, A. H., and Jan, M. Q. (1997). Geology and tectonics of Pakistan. Graphic publishers.

Klinger, F. and Ahmed, M.I. (1967). Barite deposits near Khuzdar, Kalat Division, West Pakistan, Geol. Sur. Pak. Quetta.

Khan, I. H., and Clyde, W. C. (2013). Lower Paleogene tectono-stratigraphy of Balochistan: evidence for time-transgressive Late Paleocene-Early Eocene uplift. Geosciences, 3(3), 466-501.

Large, D.E., (1980). Geological parameters associated with sediment-hosted, submarine exhalative Pb-Zn deposits. An empirical model for mineral exploration: Geologisches Jahrbuch, v. D40, p. 59–129.

Large, D.E., (1983). Sediment-hosted massive sulphides lead-zinc deposits. An empirical model, in Sangster, D.F., ed., Sediment-hosted stratiform lead-zinc deposits: Mineralogical Association of Canada Short Course Handbook, v. 9, p. 1–29.

Large, R.R., Bull, S.W., McGoldrick, P.J., Walters, Steve, Derrick, G.M., and Carr, G.R., (2005). Stratiform and stratabound Zn-Pb-Ag deposits in Proterozoic sedimentary basins, northern Australia, Economic geology. One hundredth anniversary volume, 1905–2005: Littleton, Colo., Society of Economic Geologists, 931–963 p.

Leach, D.L., Marsh, Erin, Emso, Poul, Rombach, C.S., Kelley, K.D., and Anthony, Mike, (2004). Nature of hydrothermal fluids at the shale-hosted Red Dog Zn-Pb-Ag deposits, Brooks Range, Alaska: Economic Geology, v. 99, no. 7, p. 1449–1480.

Leach, D.L., Sangster, D.F., Kelley, K.D., Large, R.R., Garven, Grant, Allen, C.R., Gutzmer, Jens, and Walters, S., (2005b). Sediment-hosted lead-zinc deposits. A global perspective, in Economic geology One hundredth anniversary volume, 1905–2005: Littleton, Colo., Society of Economic Geologists, p. 561–607.

Leach, D. L., Bradley, D. C., Huston, D., Pisarevsky, S. A., Taylor, R. D., and Gardoll, S. J. (2010). Sediment-hosted lead-zinc deposits in Earth history. Economic Geology, 105(3), 593-625.

Lydon, J.W., (1983). Chemical parameters controlling the origin and deposition of sediment-hosted stratiform lead-zinc deposits, in Sangster, D.F., ed., Sediment-hosted stratiform lead-zinc deposits: Mineralogical Association of Canada Short Course Handbook, v. 9, p. 175–250.

Lydon, J.W., (1986). Models for the generation of metalliferous hydrothermal systems within sedimentary rocks, and their applicability to the Irish Carboniferous Zn-Pb deposits, in Andrew, C.J., Crowe, R.W.A., Finlay, Sean, Pennell, W.M., and Pyne, J.F., eds., Geology and genesis of mineral deposits in Ireland: Dublin, Irish Association for Economic Geology, p. 555–577.

Lydon, J. W. (1989). Report on an examination of Zn-Pb-Ba deposits of the Lasbela-Khuzdar belt, Balochistan, Pakistan. Rept. UNDP.

Lydon, J.W., (1995). Sedimentary exhalative sulphides (SEDEX), in Eckstrand, O.R., Sinclair, W.D., and Thorpe, R.I., eds., Geology of Canadian mineral deposit types: Geological Survey of Canada, Geology of Canada Series no. 8, p. 130–152.

Lydon, J. W., and Goodfellow, W. D. (2007). Geology and metallogeny of the Belt-Purcell Basin. Geological Association of Canada, Mineral Deposits Division, 581-607.

Morris, P. (2020). Using regolith and spinifex chemistry to detect fault-controlled fluids in the Ngururupa area of northeastern Western Australia, with implications for Pb-Zn mineralization. Geochemistry: Exploration, Environment, Analysis, 20(1), 35-49.

Powell, C. M. (1979). A speculative tectonic history of Pakistan and surroundings. Geodynamics of Pakistan.

Russell, M.J., Solomon, Michael, and Wafshe, J.L., (1981). The genesis of sediment hosted exhalative zinc-lead deposits: Mineralium Deposita, v. 16, p. 113–127.

Sangster, D. F. (2002). The role of dense brines in the formation of vent-distal sedimentary-exhalative (SEDEX) lead–zinc deposits: field and laboratory evidence. Mineralium Deposita, 37(2), 149-157.

Sawkins, F.J., (1984). Ore genesis by episodic dewatering of sedimentary basins. Application to giant Proterozoic lead-zinc deposits: Geology, v. 12, p. 451–454.

Sawkins, F. J. (2013). Metal deposits in relation to plate tectonics (Vol. 17). Springer Science & Business Media.
Siddiqui, S. A., & Sharp, W. E. (1993). Lead smelting slags near Nal, Balochistan Province, Pakistan. *Geoarchaeology*, 8(5), 395-411.

Wilkinson, J. J. (2013). Sediment-Hosted Zinc-Lead Mineralization: Processes and Perspectives: Processes and Perspectives.

Williams, M. D., (1959). Stratigraphy of the lower Indus basin, West Pakistan: Proc. 5th World Petrol. Congr, New York, Sec, 1, 19, 337-391.

Yang, Jianwen, Bull, Stewart, and Large, R.R., (2004). Numerical investigation of salinity in controlling ore-forming fluid transport in sedimentary basins. Example of the HYC Deposit, northern Australia: Mineralium Deposita, v. 39, no. 5–6, p. 622–631.