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A note on the bornite-chalcopyrite intergrowth texture in the volcanic-hosted copper mineralization in the Dir area, northern Pakistan

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Various experimental studies have been carried out to understand the possible bornite-chalcopyrite intergrowth texture. Schwartz (1931) and Lyon (1959) have concluded from their experimental work that the bornite-chalcopyrite lamellae intergrowth texure observed in ores, begin their formation from temperatures above 470°C during extremely rapid cooling. Durazzo and Taylor (1982) suggested that supersaturation and annealing temperature have great effect on the textures produced due to bornite-chalcopyrite intergrowth. They further suggested that the nucleation and growth in the bornite and chalcopyrite system is also controlled by Cu-diffusion. According to Condit et al. (1974) and Durazzo and Taylor (1982), the presence of Cu and Fe in a sulfide melt also play a major role in chalcopyrite exsolution from bornite solid solution because these cations normally diffuse many order of magnitude faster than S in sulfides.

The bladed and lenticular shape intergrowth of chalcopyrite in the studied bornite (Fig.1) can be termed as widmastatten texture of Schwartz (1931) and Durazzo and Taylor (1982). This type of intergrowth texture can possibly be the product of either: 1. replacement of bornite by chalcopyrite (see Ray, 1930; Schouten, 1934) or 2. exolution from anomalous bornite (metastable bornite which exsolve chalcopyrite lamellae) during heating in a temperature range c. 200-250°C (see Durazzo & Taylor, 1982). In this case the chalcopyrite exsolution lamillae in the bornite matrix of the studied rocks (Fig.1) may have probably been produced due to the rapid growth of chalcopyrite in a highly supersaturated bornite matrix with chalcopyrite > 25%.

Lafitte et al. (1983; 1985) have shown that the identity of the minerals of Cu-Fe-S system, precipitating during hydrothermal synthesis at 415°C, depends on the S/Fe+Cu ratio of the initial starting material. Bornite forms at lower S/Fe+Cu ratio of the starting material while chalcopyrite forms at higher ratio. At further higher ratio corresponding to S/Fe+Cu > 2, both cubanite and Fe-rich chalcopyrite are formed.

It is therefore, assumed that bornite, which has the exsolved chalcopyrite in the studied rocks, started forming at the stage when the S/Fe+Cu ratio was lower. At the same time this ratio started increasing and resulted in the formation of chalcopyrite which was exsolved and led to the formation of intergrowth in bornite. With further increase of this ratio there was the precipitation of separate grains of chalcopyrite. This ratio, however, did not exceed 2 as it is indicated by the lack of cubanite in these rocks (see Lafitte et al., 1983; 1985).

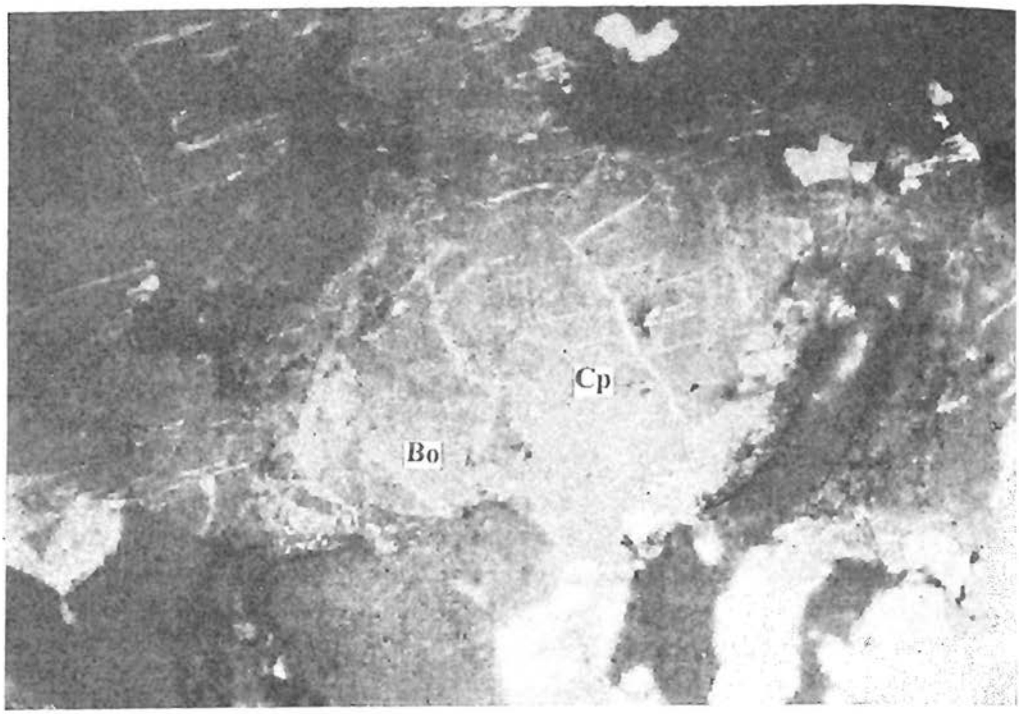

Fig. 1. Reflected-light photomicrograph showing lamillae or straight laths of chalcopyrite (Cp) in a bornite (Bo) matrix ; magnification = x50.

REFERENCES

Condit, R. H., Hobbins, R. R. & Birchenall, C. E., 1974. Self-diffusion of iron and sulfur in ferrous sulfide. Oxid., Met., 8, 409-455.

Durazzo, A. & Taylor, A. A., 1982. Experimental exsolution texture in the system bornite-chalcopyrite: genetic implications concerning natural ores. Mineralium Deposita, 17, 79-97.

Lafitte, M., Maury, R. & Perseil, E. A., 1983. Influence de la composition du milien hydrothermal de formation sur la stoichiometrie de chalcopyrites. Comparison avee les mineralsations de dorsales oceaniques. C. R. Acad. Sci. France, 11, 296, 567-570.

Lafitte, M., Maury, R., Perseil, E. A. & Boulegue., 1985. Morphological and analytical study of hydrothermal sulfides from 21 north-east Pacific Rise. Earth Planet. Sci. Lett., 73, 53-64.

Lyon, R. J. P., 1959. Time aspects of geothermometry. Mining Engineering, 11, 1145-1151.

Ray, J. R., 1930. Sulfide replacement of ore minerals. Econ. Geol., 25, 433-451.

Schouten, C., 1934. Structures and textures of synthetic replacement in "Open Space". Econ. Geol., 29, 611-658.

Schwartz, G. M., 1931. Textures due to unmixing of solid solutions. Econ. Geol., 26, 739-763.

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Stratigraphy, lithofacies and depositional environments of the Capitanian and Dzulfian strata (Permian) in the Glass Mountains, west Texas: An extended abstract

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Flanking the southern margin of the petroliferous Permian Basin, Glass Mountains, represent more than 3000 meters thick succession of chiefly carbonate Permian strata, unconformably overlying the Marathon orogenic belt (King, 1930; Ross, 1962). The area host North American regional stratotype for the Leonardian and Wordian stages and is currently a candidate for the proposed world stratotype for the Middle and Upper Permian.

The present study is focused on the stratigraphic relationships, lithofacies architecture and depositional environments of the Capitanian and Dzulfian strata (Permian), represented by the Gilliam, Capitan, Altuda and Tessey formations in the Benge Ranch area of the glass mountains, west Texas. Detailed geologic mapping, outcrop descriptions and petrographic studies are used to evaluvate and interpret lateral and vertical variation in lithology, time-stratigraphic relationships and paleoenvironments of the predominantly corbonate sequence.

The Captian strata display a classical shelf, shelf-edge, slope and basin transition of the time equivalent stratigraphic units (Haneef et al., 1990). The depositional environments recognized include: (1) The shelf facies, represented by the Gilliam Formation is dolomitic, fusulinid grainstone, stromatolitic dolostone interbedded with fine sandstone. The formation contains pisolites and tepee structures. The depositional environments are interpreted as shallowing upward stack of subtidal to supratidal shelf. (2) The shelf-edge and slope facies consists of basinward dipping and thinning carbonate wedges (foreset beds of King, 1930) interbedded with slope facies of the Altuda Formation. The lower Capitan is composed of massive bedded, vuggy, recrystallised, dolomitic mudstone to algal-sponge wackestone. The formation is characterized by large slump and slide blocks, slump folding, flame structures, ball and pillow, injection and dish structures, channelized wavy bedding and drag folding of beds caused by the overriding of debris flow tongues. The lower Capitan is interpreted as submarine debris flow deposits (Haneef, in press). The Altuda Formation in the slope and basinal facies is comprised of thin to medium -bedded (4-15cm) fine quartzose sandstone, dolomitic, silisiclastic, bioclastic wacke-packstone and dolomudstone. The formation is characterized by cyclic repetition of lithofacies, Bouma intervals, graded bedding with wavy scoured bases, diverse allochthonous fauna, planar laminations and synsedimentary deformation structures including, flame structures, dish and injection structures, and possibly escape burrows. The Bouma intervals present are AB, ABCE, ABE in order of abundance. The formation is characterized by multiple episodes of turbidity currents. A typical Bouma sequence is marked by a scoured base with shallow water bioclastic channel lag, grading upwards into fine, thinly-laminated hemipelagites containing siliceous sponge spicules, radiolaria and calcispheres. The Altuda Formation is interpreted to have formed by turbidity currents in a deep water slope to basinal setting (Haneef et al., in press). The source of sediment was from the Capitan shelf-edge and shelf environments and possibly wind-blown clastics from the coastal areas.

The stratigraphic relationships of the upper Capitan reveal that it is younger in age than the Altuda and the lower Capitan and is characterized by reefal fabric, previously unknown (see Faliskie, 1990). The upper Capitan shows three lithologically distinct facies, (1) bioclastic, dolowacke-floatstone lithofacies, (2) mixed bioclastic grain-rudstone lithofacies, and (3) algal-sponge boudstone lithofacies. A comparative analysis of the Capitan in the Guadalupe and Glass Mountains shows remarkable similarity in depositional and diagenetic fabrics. The criteria supportive of reefal origin include biotic assemblage, depositional textures and submarine cements.

The Tessey Formation unconformably overlies the Altuda Formation and represent the youngest Permian (Dzhulfian) in the Glass Mountains, Texas. The formation is characterized by three, lithologically distinct units; (1) basal, finely laminated mudstone, displaying depositional fabric analogous to nodular mosaic and chicken wire fabric of anhydrite, overlain by, 2) massive, clast-supported, spar-cemented carbonate breccia, characterized by angular, non fossiliferous clasts of limestone, quartz and chert. The rocks contain lenticular pods of conglomerate composed of genetically unrelated clasts. The presence of anhydrite fabric, solution and karst features and localized brecciation support its origin as karstified collapse breccia. These units represent precursor carbonate-evaporite cyclic deposits formed in shallowing upward salina setting (Haneef et al., in press). Climatically controlled periodic exposures of the formation resulted in meteoric flushing of evaporites developing karst landscape. The chaotic bedding is the direct result of localized collapse of the suprastructure under overburden. The unit 3 of the Tessey Formation is represented by matrix-supported dolomudstone breccia. The clasts are predominantly tabular, non fossiliferous and display fenestral fabric and algal lamination and bird's eye structures. The formation has an unconformable contact with the Cretaceous strata marked by well developed paleosol horizons. This unit shows deposition in a supratidal/sabkha type setting which is known to have existed during the final stages of the filling up of the Hovey Channel in west Texas (Ross, 1986).

REFERENCES

Faliskie, R. A., 1989. Depositional environments of the Vidrio Member of the Word, Altuda, and Capitan Formation (Upper Permian) in the northwestern Glass Mountains, west Texas. Unpubl. M.S. thesis. Sul Ross State University, Texas. USA.

Haneef, M., 1993. Lithofacies and depositional environments of Altuda, Capitan and Tessey Formations (Permian), Glass Mountains, Texas. Unpubl. M.S. thesis, Sul Ross State University, Texas, USA.

Haneef, M., Rudine, S. F., & Wardlaw, B. R., 1990. Shelf to basin transition in the Capitanian (Permian) deposition in the Glass Mountains, west Texas: Geol. Soc. Amer., Abstract with Programs, 22, A46.

Haneef, M., (in press). Anatomy and origin of Capitan foreset beds in the Glass Mountains, west Texas. In: Smithsonian Contribution to Paleobiology (Grant, R. E., Wardlaw, B. R., & D. M. Rohr, eds.) Guadalupian Symposium Volume, Washington, DC.

Haneef, M., Wardlaw, B. R., & Rohr, D. M., (in press). Lithofacies and depositional history of the Tessey Formation, Frenchman Hills, west Texas. In: Smithsonian Contribution to Paleobiology, (Grant, R. E., Wardlaw, B. R., & D. M. Rohr, eds.) Guadalupian Symposium Volume, Washington, DC.

Haneef, M., Wardlaw, B. R., & Rohr, D. M., (in press). A deep water turbidity origin for the Altuda Formation in its northernmost distribution in the Glass Mountains, Texas. In: Smithsonian Contribution to Paleobiology, (Grant, R. E., Wardlaw, B. R., & D. M. Rohr, eds.) Guadalupian Symposium Volume, Washington, DC.

King, P. B., 1930. Geology of the Glass Mountains, Texas, Part I, Descriptive Geology Bull. Univ. Texas, Austin, 3038, 167pp.

Ross, C. A., 1962. Permian tectonic history in Glass Mountains, Texas. AAPG Bull., 46, 1728-1746.

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Occurrence of maucherite in Shangla (Swat), northwestern Pakistan

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Besides zoned grains of chrome spinel, the variably altered ultramafic rocks of the Swat valley ophiolite, northwestern Pakistan, contain trace amounts of highly reflectant phases. These are mostly sulphides. However, the finely disseminated, discrete grains in some of the completely serpentinized samples from the Barkotaki village in Shangla were found to be of arsenide. The chemical composition of this latter phase is rather simple and consists almost entirely of Ni (57.33-59.14 at.%) and As (39.11-41.04 at.%) with only traces of Fe (<0.06-0.33 at.%), Co (0.83-1.02 at.%), and S (0.28-0.66 at.%). The calculated metal (Ni + Fe + Co + Cu) to arsenic ratio ranges from 1.406-1.514 and corresponds to that of maucherite (Ni_3As_2), one of the three arsenides of nickel (i.e. niccolite, maucherite and orcelite or rammelsbergite) (see Table 1).

TABLE 1: COMPOSITION (ATOMIC PERCENT) OF MAUCHERITE

No.	1	2	3	4	5	6	7	8	9	10	11
Ni	59.14	59.06	57.33	58.27	58.78	58.60	59.05	58.75	58.58	58.20	58.99
Fe	0.02	0.02	0.17	0.17	0.05	0.07	0.05	0.03	0.02	0.25	0.33
Co	0.87	0.86	0.91	0.92	0.83	0.97	0.90	0.97	0.91	0.98	0.87
Cu	0.07	0.04	0.01	0.06	0.05	0.12	0.07	0.06	0.02	0.09	0.02
S	0.56	0.56	0.52	0.58	0.42	0.58	0.42	0.46	0.54	0.42	0.66
As	39.33	39.44	41.04	39.99	39.86	39.66	39.51	39.72	39.92	40.05	39.11
Sb	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M/As	1.51	1.50	1.41	1.46	1.48	1.48	1.50	1.49	1.47	1.47	1.51
No.	12	13	14	15	16	17	18	19	20	21	22
Ni	58.58	58.85	58.64	58.90	58.43	58.66	58.73	58.44	58.58	58.60	58.57
Fe	0.06	0.02	0.12	0.08	0.15	0.20	0.15	0.08	0.04	0.12	0.08
Co	1.01	0.94	0.92	0.97	1.02	0.95	0.95	0.96	0.96	0.91	0.95
Cu	0.12	0.01	0.01	0.00	0.02	0.03	0.01	0.08	0.05	0.03	0.02
S	0.46	0.28	0.54	0.42	0.48	0.51	0.64	0.44	0.48	0.60	0.56
As	39.77	39.88	39.77	39.62	39.90	39.66	39.52	39.99	39.89	39.74	39.82
Sb	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M/As	1.49	1.49	1.48	1.50	1.48	1.49	1.49	1.47	1.48	1.48	1.48

The very low abundance of As in ultramafic rocks precludes the possibility of formation of As-rich phases in such rocks through primary magmatic processes. All the ultramafic rocks from the Swat valley are invariably serpentinized to varying degrees. In contrast, the distribution of maucherite is extremely localized. This suggests that the formation of maucherite cannot be ascribed to the process of serpentinization. Alternatively, it is postulated that a later episode of hydrothermal alteration by arsenic-bearing fluids may have led to the development of this phase. As gersdorffite (a sulpharsenide of Ni) occur both as inclusions within grains of emerald and as veins in the talc-magnesite rocks from the emerald mines area in Swat (see Gübelin, 1989; Arif, 1994), it seems that the formation of As-rich phases and emerald mineralization are genetically related phenomena.

REFERENCES

Arif, M., 1994. Studies of ultramafic rocks from Swat, northwestern Pakistan: Implications for the genesis of emerald and nickeliferous phases. Unpubl. Ph. D. thesis, Univ. Leicester, UK.

Gübelin, E. J., 1989. Gemological characteristics of Pakistani emeralds. In: Emeralds of Pakistan (A. H. Kazmi, & L. W. Snee, eds.). Van Nostrand Reinhold, New York, 75-92.