UDK 55
ISSN 0537-846X

GEOINSTITUT

R A D O V I

RADOVI Geoinstituta, knjiga 39, Beograd 2004.

Autori su naučno odgovorni za svoja izlaganja

U troškovima izdavanja ovog broja časopisa "RADOVI" učestvovalo je:
MINISTARSTVO ZA NAUKU I TEHNOLOGIJU, Beograd, Nemanjina 22-24

RADOVI Geoinstituta, Knjiga 39, Beograd, 2004.
Bulletin of Geoinstitute, vol. 39, 2004, Belgrade

SADRŽAJ

Pregledni radovi

Originalni naučni radovi

RADOVI Geoinstituta, Knjiga 39, Beograd, 2004.
Bulletin of Geoinstitute, vol. 39, 2004, Belgrade

BIBLID 0537-846X (2004), 39, p. 221-228
UDK 548.73+666.32
Stručni rad

Pavle Tančić*
Vesna Janežić*

RENDGENSKA ISPITIVANJA OPEKARSKO-KERAMIČKIH GLINA IZ LEŽIŠTA "SREDNJA STRANA" - NOVI BEČEJ

Ključne reči: Novi Bečej, ležište, rendgenska ispitivanja, mineralni sastav, kvarc, gline, feldspati, karbonati.

Izvod: Rendgenskom metodom ispitani su brojni uzorci iz slojeva keramičkih, opekarskih i podinskih glina, kao i zajedničkih kompozita iz ležišta "Srednja strana" – Novi Bečej, koji su upoređeni sa hemijskim i granulometrijskim ispitivanjima.

Rezultati dobijeni rendgenskim i hemijskim ispitivanjima su u vrlo dobroj saglasnosti, dok rezultati koji su dobijeni pomoću granulometrijske metode pokazuju nešto veće neslaganje.

Sva ispitivanja ukazuju da je mineralni, hemijski i granulometrijski sastav opekarskih glina i zajedničkih kompozitnih uzoraka povoljniji od sastava keramičkih glina.

Ustanovljena je promena mineralnog sastava sa dubinom, a najkarakterističnije je da zastupljenost karbonata opada od površine sa dubinom, dok sadržaj glinovitih minerala i feldspata raste.

U slojevima keramičkih i opekarskih glina glinoviti minerali su dva do tri puta zastupljeniji od feldspata, dok je u sloju podinskih glina njihova zastupljenost približno ista.

Kvarc je u svim slojevima najzastupljeniji mineral, a od minerala glina to su montmorionit i ilit. Zastupljenost vermikulita opada sa dubinom. Kaolinita i hlorita uglavnom ima malo, a nešto više ih ima u sloju opekarskih glina.

UVOD

Ležište opekarskih i keramičkih glina "Srednja strana" je novo ležište koje je otkriveno i istraženo u periodu 2001/02 god. (I l i ć, 2003).

Produktivni deo ležišta (opekarske i keramičke gline) čine lesne tvorevine, čija je ukupna debljina u domenu istraživanog dela (36 ha) oko 9 m.

Opekarsko-keramičku sirovinu ležišta sačinjavaju tri posebna sloja:

- sloj keramičkih glina,
- sloj opekarskih glina i
- sloj podinskih glina.

Detaljni geološki stub ovog ležišta, debljine ovih slojeva i njihove tehnološke karakteristike prikazane su kod I l i ć-a (2003).

U ovom radu su prikazani rezultati ispitivanja koji su dobijeni rendgenskom difrakcionom metodom, a koji su upoređeni sa rezultatima hemijskih i granulometrijskih ispitivanja.

* Geoinstitut, Beograd, Rovinjska 12, e-mail: geoins@beotel.yu

Na ovaj način su proučene i ispitane karakteristike sedimenata koji sačinjavaju produktivnu seriju i utvrđene promene mineralnog sastava sa dubinom ovog ležišta.

PRIPREMA MATERIJALA I PRIMENJENE METODE ISPITIVANJA

Rendgenska ispitivanja uzoraka su izvršena na rendgenskom difraktometru za prah "PHILIPS", tip PW 1009 i PW 1051.

Upotrebljeno je kobaltno zračenje talasne dužine λCoK_α=1,79026Å, koje je filtrirano β-filtrom od gvožđa. Anodno opterećenje je iznosilo: U=40 kV i I=8 mA. Brzina kretanja goniometra je iznosila $V_g=1^\circ$ 2θ/min, a brzina kretanja papira 400 mm/h. Korišćen je GM brojač sa sredinom platoa na 1550V. Osetljivost je bila 640 imp/s puna skala, a RC konstanta 4s.

Uzorci su sprašeni, a preparati napravljeni u standardnom aluminijumskom ramu dimenzija 20 x 10 x 1,5mm, a zatim je snimljeno ugaono područje 2θ od 4° do 76°.

Obavljeno je merenje Bragg-ovih uglova (2θ), i na osnovu tih vrednosti izračunata su međupljosna rastojanja (d).

Identifikacija prisutnih mineralnih faza urađena je upoređivanjem međupljosnih rastojanja (d) i relativnih intenziteta (I) sa odgovarajućim podacima iz literature (JCPDS). Difraktogrami dobijeni na ovaj način su korišćeni da bi se ustanovio mineralni sastav celog uzorka.

Glinovita frakcija (< 5μm) ispitivana je u ugaonom području 2θ od 2° do 16°, kao orijentisani preparati na glatkoj površini stakla, i to: netretirani, tretirani glicerinom i žareni na 450°C. Za svaki uzorak snimljena su po tri difraktograma (IIN, IIGL i II450°C).

REZULTATI I DISKUSIJA

Rendgenska ispitivanja obavljena su na kompozitnim uzorcima koji su sastavljeni od sledećeg materijala:

- keramičkih glina,
- opekarskih glina,
- keramičkih i opekarskih glina zajedno i
- podinskih glina.

Rezultati navedenih ispitivanja su prikazani kroz posebna poglavlja i tabelarno radi bolje preglednosti i lakšeg praćenja promene sirovine sa dubinom.

U okviru rendgenskih ispitivanja prikazani su kvalitativni-semikvantitativni sastavi, t.j. identifikovani minerali prema stepenu zastupljenosti u celom uzorku, kao i glinovite komponente.

Dobijeni rezultati su praćeni kratkim komentarima o semikvantitativnoj proceni njihove zastupljenosti, koji treba da doprinesu boljem razumevanju.

1. Sloj keramičkih glina

U okviru ispitivanja sloja keramičkih glina ispitana su tri uzorka.

Identifikovan ukupni mineralni sastav, sastav glinovite komponente i kratak komentar za uzorke keramičkih glina prikazani su u Tabeli 1.

Tabela 1: Mineralni sastav, sastav glinovite komponente i komentar za uzorke keramičkih glina.

uzorak	>5μm	< 5μm	komentar
A-58401	Kvarc, dolomit, gline, kalcit i feldspati.	Ilit, montmorionit, vermikulit i neznatno kaolinit i hlorit.	Dolomit i gline su približno podjednake zastupljenosti, kao i kalcit i feldspati, kojih ima približno dvostruko manje od dolomita.
A-58406	Kvarc, gline, kalcit, feldspati i dolomit.	Montmorionit, ilit, vermikulit i neznatno kaolinit.	Glina ima nešto više od kalcita. Feldspati su dvostruko manje zastupljeni od kalcita, dok dolomita ima vrlo malo.
A-58410	Kvarc, dolomit, gline, kalcit i feldspati.	Montmorionit, ilit, vermikulit i neznatno kaolinit i hlorit.	Glina ima nešto manje od dolomita, dok kalcita i feldspata (koji su približno podjednake zastupljenosti) ima dvostruko manje.

Rezultati koji su dobijeni hemijskim i granulometrijskim ispitivanjima keramičkih glina (I l i ć, 2003) prikazani su u Tabelama 2 i 3.

Tabela 2: Hemijski sastavi uzoraka keramičkih glina.

uzorak	SiO_2	Al_2O_3	$Fe_{(uk)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	G.Ž.
A-58401	51,89	8,73	3,23	1,05	11,10	4,51	0,07	1,14	1,80	1,28	15,16
A-58406	61,85	13,91	4,39	1,37	2,88	2,24	0,11	1,43	2,52	2,36	6,92
A-58410	53,88	9,33	2,91	1,11	9,17	4,14	0,08	1,09	1,93	1,36	14,58

Tabela 3: Rezultati granulometrijskih ispitivanja uzoraka keramičkih glina.

uzorak	frakcija (%)			pros. vel. zrna (mm)	S_o	S_k	0,02-0,005 mm
	peskovita	alevritska	glinovita				
A-58401	9,96	89,04	1,00	0,040	1,402	0,908	25,00
A-58406	8,32	90,68	1,00	0,032	1,692	0,863	46,00
A-58410	8,04	90,96	1,00	0,036	1,600	0,805	38,00

2. Sloj opekarskih glina

U okviru ispitivanja sloja opekarskih glina ispitano je deset uzoraka.

Identifikovan ukupni mineralni sastav, sastav glinovite komponente i kratak komentar za uzorke opekarskih glina prikazani su u Tabeli 4.

Tabela 4: Mineralni sastav, sastav glinovite komponente i komentar za uzorke opekarskih glina.

uzorak	>5μm	< 5μm	komentar
A-58413	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit, kaolinit i vermikulit.	Feldspati, kalcit i dolomit su male zastupljenosti.
A-58416	Kvarc, dolomit, gline, feldspati i kalcit.	Montmorionit, ilit, kaolinit, vermikulit i hlorit.	Dolomit i gline su približno podjednake zastupljenosti, kao i feldspati i kalcit, kojih ima približno dvostruko manje.
A-58422	Kvarc, gline, feldspati, dolomit i kalcit.	Montmorionit, ilit i neznatno vermikulit i kaolinit.	Glina ima dvostruko više od feldspata, dok su dolomit i kalcit male zastupljenosti.
A-58428	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit i neznatno kaolinit.	Feldspati, kalcit i dolomit su male zastupljenosti u odnosu na kvarc i gline.
A-58430	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit i manje vermikulit i kaolinit.	Feldspata i kalcita ima približno podjednako, a dolomita neznatno.

A-58432	Kvarc, gline, feldspati i kalcit.	Montmorionit, ilit i manje vermikulit i kaolinit.	Feldspata i kalcita ima malo, a dvostruko manje od glina.
A-58434	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit i manje vermikulit.	Glina ima dvostruko više od feldspata, dok su kalcit i dolomit vrlo male zastupljenosti.
A-58437	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit i manje vermikulit i kaolinit.	Glina ima nešto više od feldspata, dok su kalcit i dolomit vrlo male zastupljenosti.
A-58441	Kvarc, gline, feldspati, kalcit, i dolomit.	Montmorionit, ilit, kaolinit i manje vermikulit i hlorit.	Glina ima dvostruko više od feldspata, kalcita i dolomita.
A-58444	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit, kaolinit i manje vermikulit i hlorit.	Glina ima trostruko više od feldspata, kalcita i dolomita.

Rezultati koji su dobijeni hemijskim i granulometrijskim ispitivanjima opekarskih glina (I l i ć, 2003) prikazani su u Tabelama 5 i 6.

Tabela 5: Hemijski sastavi uzoraka opekarskih glina.

uzorak	SiO_2	Al_2O_3	$Fe_{(uk)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	G.Ž.
A-58413	59,93	13,46	5,18	1,53	2,97	2,23	0,09	1,48	2,80	2,25	7,28
A-58416	53,69	9,03	3,75	1,28	9,43	3,89	0,07	1,13	1,88	1,34	14,30
A-58422	61,88	13,10	5,50	1,47	2,31	2,07	0.09	1,42	2,22	1,98	6,84
A-58428	59,32	13,77	5,65	1,61	3,47	2,05	0,10	1,30	2,72	1,94	7,90
A-58430	59,32	13,85	5,56	1,54	2,53	2,29	0,09	1,36	3,09	2,45	7,67
A-58432	60,24	13,62	5,05	1,60	2,60	2,45	0,09	1,19	2,95	3,90	6,34
A-58434	63,75	13,39	1,66	1,48	3,44	2,23	0,11	1,21	2,65	2,82	6,60
A-58437	62,82	12,49	4,60	1,52	2,99	2,26	0,07	1,40	2,61	2,68	6,26
A-58441	58,01	13,15	5,94	1,41	3,87	2,29	0,14	1,01	2,72	3,26	8,18
A-58444	59,64	13,39	5,57	1,40	3,27	2,07	0,11	1,02	2,58	3,04	7,44

Tabela 6: Rezultati granulometrijskih ispitivanja uzoraka opekarskih glina.

uzorak	frakcija (%)			pros. vel. zrna (mm)	S_o	S_k	0,02-0,005 mm
	peskovita	alevritska	glinovita				
A-58413	6,34	91,66	2,00	0,041	1,624	1,146	68,00
A-58416	8,50	89,50	2,00	0,046	1,226	1,002	4,00
A-58422	9,90	89,10	1,00	0,038	1,528	1,832	32,00
A-58428	11,26	87,74	1,00	0,044	1,577	0,823	34,00
A-58430	5,18	90,82	4,00	0,023	1,628	1,114	69,00
A-58432	9,02	86,98	4,00	0,028	1,835	1,015	53,00
A-58434	6,30	90,70	3,00	0,030	1,762	0,907	50,00
A-58437	4,24	92,76	3,00	0,041	1,720	0,069	60,00
A-58441	18,04	78,96	3,00	0,049	1,998	1,130	50,00
A-58444	15,46	81,54	3,00	0,034	1,926	1,057	50,00

3. Zajednički kompoziti

U okviru ispitivanja zajedničkih kompozita ispitano je šest uzoraka.

Pod pojmom "zajedničkih kompozita" se podrazumevaju kompozitni uzorci koji su sačinjeni od kompletnog keramičkog i kompletnog opekarskog sloja. U tom smislu ispitivanjima je obuhvaćen samo deo ležišta sa utvrđenim rezervama A kategorije.

Identifikovan ukupni mineralni sastav, sastav glinovite komponente i kratak komentar za uzorke zajedničkih kompozita prikazani su u Tabeli 7.

Tabela 7: Mineralni sastav, sastav glinovite komponente i komentar za uzorke zajedničkih kompozita.

uzorak	>5μm	< 5μm	komentar
A-58449	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit, kaolinit i neznatno vermikulit.	Glina ima dvostruko više od feldspata, kalcita i dolomita.
A-58453	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit, kaolinit i manje vermikulit.	Glina ima dvostruko više od feldspata, kalcita i dolomita.
A-58457	Kvarc, gline, kalcit, feldspati i dolomit.	Montmorionit, ilit, kaolinit i neznatno vermikulit.	Kalcita ima nešto manje od glina, dok su feldspati i dolomit približno podjednake zastupljenosti.
A-58461	Kvarc, gline, feldspati i kalcit.	Montmorionit, ilit i neznatno vermikulit i kaolinit.	Minerala glina ima skoro tri puta više od feldspata i kalcita.
A-58465	Kvarc, gline, feldspati i kalcit.	Montmorionit, ilit i neznatno vermikulit, kaolinit i hlorit.	Glina ima skoro tri puta više od feldspata i kalcita.
A-58466	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit i neznatno kaolinit.	Glina i feldspata ima približno podjednako, isto kao i kalcita i dolomita, a koji su znatno manje zastupljeni.

Rezultati koji su dobijeni hemijskim i granulometrijskim ispitivanjima zajedničkih kompozita (I l i ć, 2003) prikazani su u Tabelama 8 i 9.

Tabela 8: Hemijski sastavi uzoraka zajedničkih kompozita.

uzorak	SiO_2	Al_2O_3	$Fe_{(uk)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	G.Ž.
A-58449	57,89	13,49	5,05	1,45	5,02	2,22	0,09	1,49	2,53	2,74	7,94
A-58453	60,31	13,41	4,85	1,65	3,58	2,16	0,10	1,46	2,68	2,78	7,10
A-58457	52,20	11,19	3,99	1,28	9,63	3,06	0,06	1,14	2,09	2,04	13,22
A-58461	58,49	14,14	5,54	1,34	3,51	2,17	0,09	1,26	2,71	3,06	7,62

Tabela 9: Rezultati granulometrijskih ispitivanja uzoraka zajedničkih kompozita.

uzorak	frakcija (%)			pros. vel. zrna (mm)	S_o	S_k	0,02-0,005 mm
	peskovita	alevritska	glinovita				
A-58449	13,14	84,86	2,00	0,045	1,749	0,818	41,00
A-58453	12,32	85,68	2,00	0,063	1,660	0,799	36,00
A-58457	12,90	84,10	3,00	0,041	1,686	0,786	35,00

4. Sloj podinskih glina

Plave, dosta masne gline čine podinu produktivnog sloja. Jasno se razlikuju od prethodnih slojeva po boji, makroskopskom izgledu i genetskim karakteristikama (I l i ć, 2003).

U okviru ispitivanja sloja podinskih glina ispitano je pet uzoraka.

Identifikovan ukupni mineralni sastav, sastav glinovite komponente i kratak komentar za uzorke podinskih glina prikazani su u Tabeli 10.

Tabela 10: Mineralni sastav, sastav glinovite komponente i komentar za uzorke podinskih glina.

uzorak	>5μm	< 5μm	komentar
A-58346	Kvarc, feldspati, gline, Mg-kalcit, kalcit i dolomit.	Ilit i montmorionit.	Kvarc preovlađuje, dok glina i karbonata ima vrlo malo.
A-58347	Kvarc, gline, feldspati, kalcit i dolomit.	Montmorionit, ilit i hlorit.	Kvarc preovlađuje, feldspata i kalcita ima približno podjednako, dok dolomita ima nešto manje.
A-58356	Kvarc, feldspati, gline, Mg-kalcit i dolomit.	Montmorionit i ilit.	Kvarc preovlađuje, feldspata i glina ima približno podjednako, dok su karbonati malo zastupljeni.
A-58357	Kvarc, feldspati i gline.	Montmorionit, ilit i hlorit.	Kvarc dominira nad ostalim mineralnim vrstama.
A-58393	Kvarc, feldspati, gline i Mg-kalcit.	Montmorionit i ilit.	Feldspati i gline su približno podjednake zastupljenosti, dok je Mg-kalcit vrlo malo zastupljen.

Iz rezultata koji su prikazani u Tabelama 1, 4, 7 i 10, a koji se odnose na mineralni sastav koji je ustanovljen rendgenskim ispitivanjima, mogu se izvući sledeći zaključci:

Kvarc je u svim slojevima najzastupljeniji mineral.

Od minerala glina u svim slojevima najzastupljeniji su montmorionit i ilit. Vermikulit je najzastupljeniji u sloju keramičkih glina, mnogo manje ga ima u sloju opekarskih glina, dok ga u sloju podinskih glina nema uopšte. Kaolinit i hlorit su, uglavnom, vrlo male zastupljenosti, a ima ih nešto više u sloju opekarskih glina.

Minerala glina u slojevima keramičkih i opekarskih glina ima više od feldspata, dok ih u sloju podinskih glina ima približno kao i feldspata.

Feldspata (u odnosu na minerale glina) ima manje u keramičkim i opekarskim slojevima, dok su u sloju podinskih glina približno iste zastupljenosti.

Karbonata (kalcita, dolomita, i ponegde Mg-kalcita) ima najviše u sloju keramičkih glina, dok u slojevima opekarskih i podinskih glina njihova zastupljenost opada toliko da ih ima čak i do dva i tri puta manje od minerala glina.

Kompozitni uzorci se uglavnom sastoje od kvarca, minerala glina (montmorionitsko-ilitskog, neznatno kaolinitsko-vermikulitsko-hloritskog sastava), feldspata, kalcita i dolomita. Minerala glina i feldspata ponegde ima u skoro podjednakom odnosu, a uglavnom glinovitih minerala ima dva do tri puta više od feldspata i karbonata.

U Tabelama 2, 5 i 8 prikazani su rezultati hemijskih ispitivanja kompozitnih uzoraka produktivnog sloja, tj. sloja keramičkih i opekarskih glina i njihovih zajedničkih kompozita.

U Tabeli 11 prikazane su vrednosti uporednog srednjeg hemijskog sastava sirovine po pojedinim slojevima. Nažalost, sloj podinskih glina nije hemijski analiziran.

Tabela 11: Srednji hemijski sastavi keramičkih i opekarskih glina i zajedničkih kompozita.

Glina	SiO_2	Al_2O_3	$Fe_{(uk)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	G.Ž.
Keramička	55,88	10,95	4,10	1,04	6,57	3,45	0,79	1,16	2,17	1,86	11,77
Opekarska	58,55	12,09	4,80	1,44	4,58	2,74	0,09	1,28	2,45	2,19	9,32
Zaj. komp.	58,00	11,81	4,45	1,45	4,85	2,50	0,87	1,27	2,43	2,46	8,55

Što se tiče hemijskih komponenti, mogu se izvesti sledeći zaključci:
Sadržaji SiO_2, Al_2O_3, Na_2O, K_2O i H_2O rastu sa dubinom i
Sadržaji CaO, MgO, MnO i G.Ž. opadaju sa dubinom.

ZAKLJUČAK

Rendgenskom metodom ispitani su brojni uzorci iz slojeva keramičkih, opekarskih i podinskih glina, kao i zajedničkih kompozita iz ležišta "Srednja strana" – Novi Bečej.

Identifikovani su mineralni sastavi u celom uzorku (> 5μm), a takođe i glinovite komponente (< 5μm).

Rezultati ispitivanja koji su dobijeni rendgenskom difrakcionom metodom upoređeni su sa rezultatima hemijskih i granulometrijskih ispitivanja.

Na osnovu rezultata ovih laboratorijskih ispitivanja koji su prikazani u Tabelama 1-11 može se izvesti nekoliko zaključaka o promenama mineraloškog, hemijskog i granulometrijskog sastava, koje su prvenstveno rezultat uslova njihove geneze (I l i ć, 2003).

U tom smislu najkarakterističnije je da zastupljenost karbonata opada od površine prema dubini, dok sadržaj glinovitih minerala i feldspata raste.

U međusobnom odnosu glinovitih minerala i feldspata može se videti da su u slojevima keramičkih i opekarskih glina glinoviti minerali dva, pa čak i tri puta zastupljeniji od feldspata, dok su u sloju podinskih glina približno iste zastupljenosti.

Sva ispitivanja ukazuju da je mineraloški, hemijski i granulometrijski sastav opekarskih glina i zajedničkih kompozitnih uzoraka mnogo povoljniji od sastava keramičkih glina.

Takođe, iz prikazanih rezultata može se videti da su rezultati rendgenskih i hemijskih ispitivanja u vrlo dobroj korelaciji, dok sa granulometrijskim pokazuju nešto veće neslaganje.

Naime:

Tamo gde je rendgenskom metodom konstatovan veći sadržaji karbonata, veći su i sadržaji CaO, MgO i G.Ž. koji su dobijeni hemijskom analizom.

Tamo gde su rendgenskom metodom minerali glina i feldspati konstatovani sa većom zastupljenošću, povišeni su i sadržaji SiO_2, Al_2O_3, Na_2O i K_2O koji su dobijeni hemijskom analizom.

Ako su glinoviti minerali zastupljeniji od feldspata i karbonata, raste i sadržaj H_2O.

Tamo gde je rendgenskim ispitivanjima ustanovljen porast sadržaja glinovitih minerala, to je takođe potvrđeno i granulometrijskim ispitivanjima. Međutim, taj sadržaj glinovite komponente kod granulometrijskih ispitivanja je manji nego što ukazuju rendgenska i hemijska ispitivanja.

U našoj stručnoj literaturi postoji priličan nedostatak predstavljanja rezultata na ovaj način, a pogotovu identifikovanog mineralnog, hemijskog i granulometrijskog sastava pojedinih slojeva, kao i celog ležišta.

Takođe, retko se mogu videti uporedni rezultati dobijeni pomoću nekoliko različitih metoda.

Zbog toga, nadamo se da će predstavljeni rezultati doprineti boljem razumevanju geologije i mineralogije sa ovih prostora.

Recenzent: Dr. Mihovil Logar, redovan profesor

LITERATURA

1.Bailey and Tyler, 1960: JCPDS 13-0003, Chlorite, Econ. Geol., 55, 150.

2.Blanchard, F., 1991: JCPDS 43-0697, Calcite, magnesian, Dept. of Geology, Univ. of Florida, Gainesville, Florida, USA, ICDD Grant-In-Aid.

3.Borg and Smith 1969, JCPDS 22-0687, Microcline, Am. Mineral., 54, 163.

4.Brindley, G., 1977: JCPDS 29-1488, Kaolinite, Penn State Univ., University Park, PA, USA, ICDD Grant-In-Aid.
5.Brindley, G., 1977: JCPDS 29-1498, Montmorillonite, Penn State Univ., University Park, PA, USA, ICDD Grant-In-Aid.
6.Ilić, B., 2003: Elaborat o rezervama keramičkih i opekarskih glina u ležištu "Srednja strana", FSD Geoinstituta, Beograd.
7.Keller, L. and McCarthy, G., 1985: JCPDS 36-0426, Dolomite, North Dakota State Univ., Fargo, ND, USA, ICDD Grant-In-Aid.
8.Kern, A. and Eysel, W., 1993: JCPDS 46-1045, Quartz, Mineralogisch-Petrograph. Inst., Univ. Heidelberg, Germany, ICDD Grant-In-Aid.
9.Mukherjee, 1963: JCPDS 16-0613, Vermiculite, Clay Miner. Bull., 5, 194.
10.Sanc, I., 1990: JCPDS 41-1486, Anorthite, Polytechna, Foreign Trade Corporation, Panska, Czechoslovakia, ICDD Grant-In-Aid.
11.Shimoda, S., 1970: JCPDS 43-0685, Illite, Clays, Clay Miner., 18, 269.
12.Smith 1956: JCPDS 10-0393, Albite, Mineral. Mag., 31, 47.
13.Swanson, H. E. and Fuyat, R. K., 1953: JCPDS 05-0586, Calcite, Natl. Bur. Stand. (U.S.), Circ. 539, II, p. 51.
14.Visser, J., 1966: JCPDS 31-0966, Orthoclase, Technisch Physische Dienst, Delft, The Netherlands, ICDD Grant-In-Aid.

RADOVI Geoinstituta, Knjiga 39, Beograd, 2004.
Bulletin of Geoinstitute, vol. 39, 2004, Belgrade

BIBLID 0537-846X (2004), 39, p. 229-236
UDK 548.73+666.32
Stručni rad

X-RAY INVESTIGATIONS OF THE BRICK-CERAMIC CLAYS FROM THE ORE DEPOSIT "SREDNJA STRANA" - NOVI BEČEJ

by

Pavle Tančić* and Vesna Janežić*

Key words: Novi Bečej, ore deposit, X-ray investigations, mineral composition, quartz, clays, feldspars, carbonates.

Abstract: With the X-ray method there were investigated numerous samples from the layers of the ceramic, brick and substratum clays, and also collective composites from the ore deposit "Srednja strana" – Novi Bečej, which were compared with the chemical and grain-size investigations.

The results which were obtained with the X-ray and chemical investigations are in very good agreement, while the results which were obtained by grain-size method manifested something bigger disagreement.

All of the investigations indicate that mineral, chemical and grain-size compositions of the brick clays and collective composite samples are favorable than compositions of the ceramic clays.

It was established variation in the mineral composition by depth, and most characteristic is that carbonate content decrease from surface by depth, while content of the clay minerals and feldspars increase.

In the ceramic and brick clay layers clay minerals are with two to three times more content than feldspars, while in the substratum clay layer they are of approximative contents.

Quartz is in all of the layers mineral with most content, and of clay minerals that are montmorillonite and illite. Vermiculite content decrease with depth. Kaolinite and chlorite is mostly with low content, and with something more content in the brick clay level.

INTRODUCTION

The ore deposit of the brick and ceramic clays "Srednja strana" is the new ore deposit which was discovered and explored during the 2001/02 (I l i ć, 2003).

Productive part of the ore deposit (brick and ceramic clays) constitute from loess components, which total thickness in the exploration area (36 ha) is about 9 m.

Brick-ceramic raw material of the ore deposit consists from three separate layers:

- ceramic clay layer,
- brick clay layer and
- substratum clay layer.

Detail geological column of this ore deposit, thickness of this layers and their technological characteristics were represented by I l i ć (2003).

* Geoinstitute, Belgrade, Rovinjska 12, e-mail: geoins@beotel.yu

In this paper there were represented investigation results which were obtained by the X-ray diffraction method, and which were compared with the results of the chemical and grain-size investigations.

At that manner there were studied and examined characteristics of the sediments which constitute the productive series and there was established the variation of the mineral composition by depth of this ore deposit.

MATERIAL PREPARATION AND APPLIED INVESTIGATION METHODS

The X-ray investigations of the samples were performed by the X-ray diffractometer for powder "PHILIPS", model PW 1009 and PW 1051.

There was used cobalt radiation with the wave-length λCoK_α=1,79026Å, which was filtered by iron β-filter. Anode load was: U=40 kV and I=8 mA. Goniometer speed was $V_g=1^\circ$ 2θ/min, and running paper speed was 400 mm/h. It was used GM counter with mean plateau at 1550V. Sensitivity was 640 imp/s full scale, and RC constant was 4s.

Samples were powdered, and preparations were made in the standard aluminium frame with dimensions 20 x 10 x 1,5mm, and then they were recorded at angle range 2θ from 4° to 76°.

There were accomplished measurements of the Bragg angles (2θ), and at basis of that values there were calculated interplanar spacings (d).

Identification of the present mineral phases was done with comparison of the interplanar spacings (d) and relative intensities (I) with the responsable literature datas (JCPDS). Diffractograms obtained at such manner were used to establish the mineral composition of the entire sample.

Clayey fraction (< 5μm) was investigated at angle range 2θ from 2° to 16°, as oriented preparations at smooth glass surface, that is: untreated, treated with glycerine and heated at 450°C. For each sample there were recorded three diffractograms (IIN, IIGL and II450°C).

RESULTS AND DISCUSSION

The X-ray investigations were accomplished at composite samples which composed from following material:

- ceramic clays,
- brick clays,
- ceramic and brick clays together and
- substratum clays.

The results of the named investigations are represented through separate chapters and in tables because of better viewness and easier overlook of variation of the raw material by depth.

Within the X-ray investigations there were represented qualitative-semiquantitative compositions, i.e. identified minerals by their quantity of the entire sample, and also of the clay component.

Obtained results are followed by short comments of semiquantitative evaluation of their quantity which should contribute to better understanding.

1. Ceramic clay layer

Within the investigation of the ceramic clay layer there were examined three samples.

Identified entire mineral composition, composition of the clay component and short comment for the ceramic clay samples are represented at Table 1.

Table 1: Mineral composition, composition of the clay component and comment for the ceramic clay samples.

sample	>5μm	< 5μm	comment
A-58401	Quartz, dolomite, clays, calcite and feldspars.	Illite, montmorillonite, vermiculite and inconsiderable kaolinite and chlorite.	Dolomite and clays are of thereabout equally content, and also calcite and feldspars, which are of thereabout double less content than dolomite.
A-58406	Quartz, clays, calcite, feldspars and dolomite.	Montmorillonite, illite, vermiculite and inconsiderable kaolinite.	Clays are something over than calcite. Feldspars are of double less content than calcite, while dolomite is of very small content.
A-58410	Quartz, dolomite, clays, calcite and feldspars.	Montmorillonite, illite, vermiculite and inconsiderable kaolinite and chlorite.	Clays are something less than dolomite, while calcite and feldspars (which are of thereabout equally content) has double less content.

Results which were obtained by chemical and grain-size investigations of the ceramic clays (I l i ć, 2003) are represented at Tables 2 and 3.

Table 2: Chemical compositions of the ceramic clay samples.

sample	SiO_2	Al_2O_3	$Fe_{(total)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	I.L.
A-58401	51,89	8,73	3,23	1,05	11,10	4,51	0,07	1,14	1,80	1,28	15,16
A-58406	61,85	13,91	4,39	1,37	2,88	2,24	0,11	1,43	2,52	2,36	6,92
A-58410	53,88	9,33	2,91	1,11	9,17	4,14	0,08	1,09	1,93	1,36	14,58

Table 3: Results of the grain size investigations of the ceramic clay samples.

sample	fraction (%)			aver. grain size (mm)	S_o	S_k	0,02-0,005 mm
	sandy	silty	clayey				
A-58401	9,96	89,04	1,00	0,040	1,402	0,908	25,00
A-58406	8,32	90,68	1,00	0,032	1,692	0,863	46,00
A-58410	8,04	90,96	1,00	0,036	1,600	0,805	38,00

2. Brick clay layer

Within the investigation of the brick clay layer there were examined ten samples.

Identified entire mineral composition, composition of the clay component and short comment for the brick clay samples are represented at Table 4.

Table 4: Mineral composition, composition of the clay component and comment for the brick clay samples.

sample	>5μm	< 5μm	comment
A-58413	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite, kaolinite and vermiculite.	Feldspars, calcite and dolomite are of small quantity.
A-58416	Quartz, dolomite, clays, feldspars and calcite.	Montmorillonite, illite, kaolinite, vermiculite and chlorite.	Dolomite and clays are of thereabout equally content, and also feldspars and calcite, which are of thereabout double less content.
A-58422	Quartz, clays, feldspars, dolomite and calcite.	Montmorillonite, illite and inconsiderable vermiculite and kaolinite.	Clays are double over than feldspars, while dolomite and calcite are of small quantity.

A-58428	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite and inconsiderable kaolinite.	Feldspars, calcite and dolomite are of small quantity regard to the quartz and clays.
A-58430	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite and less vermiculite and kaolinite.	Feldspars and calcite are of thereabout equally quantity, while dolomite is of inconsiderable quantity.
A-58432	Quartz, clays, feldspars and calcite.	Montmorillonite, illite and less vermiculite and kaolinite.	Feldspars and calcite are of small quantity, and of double less quantity than clays.
A-58434	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite and less vermiculite.	Clays are double over than feldspars, while calcite and dolomite are of very small quantity.
A-58437	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite and less vermiculite and kaolinite.	Clays are something over than feldspars, while calcite and dolomite are of very small quantity.
A-58441	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite, kaolinite and less vermiculite and chlorite.	Clays are double over than feldspars, calcite and dolomite.
A-58444	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite, kaolinite and less vermiculite and chlorite.	Clays are triple over than feldspars, calcite and dolomite.

Results which were obtained by chemical and grain-size investigations of the brick clays (I l i ć, 2003) are represented at Tables 5 and 6.

Table 5: Chemical compositions of the brick clay samples.

sample	SiO_2	Al_2O_3	$Fe_{(total)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	I.L.
A-58413	59,93	13,46	5,18	1,53	2,97	2,23	0,09	1,48	2,80	2,25	7,28
A-58416	53,69	9,03	3,75	1,28	9,43	3,89	0,07	1,13	1,88	1,34	14,30
A-58422	61,88	13,10	5,50	1,47	2,31	2,07	0.09	1,42	2,22	1,98	6,84
A-58428	59,32	13,77	5,65	1,61	3,47	2,05	0,10	1,30	2,72	1,94	7,90
A-58430	59,32	13,85	5,56	1,54	2,53	2,29	0,09	1,36	3,09	2,45	7,67
A-58432	60,24	13,62	5,05	1,60	2,60	2,45	0,09	1,19	2,95	3,90	6,34
A-58434	63,75	13,39	1,66	1,48	3,44	2,23	0,11	1,21	2,65	2,82	6,60
A-58437	62,82	12,49	4,60	1,52	2,99	2,26	0,07	1,40	2,61	2,68	6,26
A-58441	58,01	13,15	5,94	1,41	3,87	2,29	0,14	1,01	2,72	3,26	8,18
A-58444	59,64	13,39	5,57	1,40	3,27	2,07	0,11	1,02	2,58	3,04	7,44

Table 6: Results of the grain size investigations of the brick clay samples.

sample	fraction (%)			aver. grain size (mm)	S_o	S_k	0,02-0,005 mm
	sandy	silty	clayey				
A-58413	6,34	91,66	2,00	0,041	1,624	1,146	68,00
A-58416	8,50	89,50	2,00	0,046	1,226	1,002	4,00
A-58422	9,90	89,10	1,00	0,038	1,528	1,832	32,00
A-58428	11,26	87,74	1,00	0,044	1,577	0,823	34,00
A-58430	5,18	90,82	4,00	0,023	1,628	1,114	69,00
A-58432	9,02	86,98	4,00	0,028	1,835	1,015	53,00
A-58434	6,30	90,70	3,00	0,030	1,762	0,907	50,00
A-58437	4,24	92,76	3,00	0,041	1,720	0,069	60,00
A-58441	18,04	78,96	3,00	0,049	1,998	1,130	50,00
A-58444	15,46	81,54	3,00	0,034	1,926	1,057	50,00

3. Collective composites

Under the term "collective composites" it is implied composite samples which consists from complete ceramic and complete brick layers. At that sense with the investigations it is comprehended only the part of the ore deposit with the established reserves of A category.

Within the investigation of the collective composites there were examined six samples.

Identified entire mineral composition, composition of the clay component and short comment for the collective composite samples are represented at Table 7.

Table 7: Mineral composition, composition of the clay component and comment for the collective composite samples.

sample	>5μm	< 5μm	comment
A-58449	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite, kaolinite and inconsiderable vermiculite.	Clays are double over than feldspars, calcite and dolomite.
A-58453	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite, kaolinite and less vermiculite.	Clays are double over than feldspars, calcite and dolomite.
A-58457	Quartz, clays, calcite, feldspars, and dolomite.	Montmorillonite, illite, kaolinite and inconsiderable vermiculite.	Calcite is something less than clays, while feldspars and dolomite are of thereabout equally content.
A-58461	Quartz, clays, feldspars and calcite.	Montmorillonite, illite and inconsiderable vermiculite and kaolinite.	Clays are almost triple over than feldspars and calcite.
A-58465	Quartz, clays, feldspars and calcite.	Montmorillonite, illite and inconsiderable vermiculite, kaolinite and chlorite.	Clays are almost triple over than feldspars and calcite.
A-58466	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite and inconsiderable kaolinite.	Clays and feldspars are of thereabout equally quantity, same as calcite and dolomite, which are of considerable less quantity.

Results which were obtained by chemical and grain-size investigations of the collective composites (I l i ć, 2003) are represented at Tables 8 and 9.

Table 8: Chemical compositions of the collective composite samples.

sample	SiO_2	Al_2O_3	$Fe_{(total)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	I.L.
A-58449	57,89	13,49	5,05	1,45	5,02	2,22	0,09	1,49	2,53	2,74	7,94
A-58453	60,31	13,41	4,85	1,65	3,58	2,16	0,10	1,46	2,68	2,78	7,10
A-58457	52,20	11,19	3,99	1,28	9,63	3,06	0,06	1,14	2,09	2,04	13,22
A-58461	58,49	14,14	5,54	1,34	3,51	2,17	0,09	1,26	2,71	3,06	7,62

Table 9: Results of the grain size investigations of the collective composite samples.

sample	fraction (%)			aver. grain size (mm)	S_o	S_k	0,02-0,005 mm
	sandy	silty	clayey				
A-58449	13,14	84,86	2,00	0,045	1,749	0,818	41,00
A-58453	12,32	85,68	2,00	0,063	1,660	0,799	36,00
A-58457	12,90	84,10	3,00	0,041	1,686	0,786	35,00

4. Substratum clay layer

Blue, quite greasy clays constitute the substratum of the productive layer. They are clearly distinctioned than previous layers by colour, macroscopic appearance and genetic characteristics (I l i ć, 2003).

Within the investigation of the substratum clay layer there were examined five samples.

Identified entire mineral composition, composition of the clay component and short comment for the substratum clay samples are represented at Table 10.

Table 10: Mineral composition, composition of the clay component and comment for the substratum clay samples.

sample	>5μm	< 5μm	comment
A-58346	Quartz, feldspars, clays, Mg-calcite, calcite and dolomite.	Illite and montmorillonite.	Quartz predominate, while clays and carbonates are of very small quantity
A-58347	Quartz, clays, feldspars, calcite and dolomite.	Montmorillonite, illite and chlorite.	Quartz predominate, feldspars and calcite are of thereabout equally quantity, while dolomite is of something less quantity.
A-58356	Quartz, feldspars, clays, Mg-calcite and dolomite.	Montmorillonite and illite.	Quartz predominate, feldspars and clays are of thereabout equally quantity, while carbonates are of small quantity.
A-58357	Quartz, feldspars and clays.	Montmorillonite, illite and chlorite.	Quartz predominate over the other mineral kinds.
A-58393	Quartz, feldspars, clays and Mg-calcite.	Montmorillonite and illite.	Feldspars and clays are of thereabout equally quantity, while Mg-calcite is of very small quantity.

From the results which were represented at Tables 1, 4, 7 and 10, and which are related to the mineral composition which was established by the X-ray investigations, it can be made following conclusions:

Quartz is in all of the layers most quantity mineral.

From clay minerals in all layers montmorillonite and illite are with the most content. Vermiculite is with most quantity in the ceramic clay layer, much less in the brick clay layer, while in the substratum clay layer it is not present. Kaolinite and chlorite are, mostly, with very small quantity, and they are of something more quantity in the brick clay layer.

Clay minerals in the ceramic and brick clay layers has more than feldspars, while in the substratum clay layer they are of thereabout equally quantity as feldspars.

Feldspars (regard to the clay minerals) are less in the ceramic and brick layers, while in the substratum clay layer they are of thereabout equally quantity.

Carbonates (calcite, dolomite, and somewhere Mg-calcite) are with most quantity in the ceramic clay layer, while in the brick and substratum clay layers their quantity decrease so much that they are even two to three times less than clay minerals.

Composite samples are mostly consisted from quartz, clay minerals (montmorillonite-illite, inconsiderable kaolinite-vermiculite-chlorite composition), feldspars, calcite and dolomite. Clay minerals and feldspars are somewhere of almost equally quantity, and mostly clay minerals are two to three times over than feldspars and carbonates.

At Tables 2, 5 and 8 there are represented results of the chemical investigations of the composite samples of the productive layer, i.e. ceramic and brick clay layers and their collective composites.

At Table 11 there are represented values of the comparative average chemical compositions of the raw material from individual layers. Unfortunately, layer of the substratum clays are not chemicaly analyzed.

Table 11: Average chemical compositions of the ceramic and brick clays and collective composites.

Clay	SiO_2	Al_2O_3	$Fe_{(total)}$	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	H_2O	I.L.
Ceramic	55,88	10,95	4,10	1,04	6,57	3,45	0,79	1,16	2,17	1,86	11,77
Brick	58,55	12,09	4,80	1,44	4,58	2,74	0,09	1,28	2,45	2,19	9,32
Col. comp.	58,00	11,81	4,45	1,45	4,85	2,50	0,87	1,27	2,43	2,46	8,55

Regard to the chemical components, it can be made following conclusions:
Contents of the SiO_2, Al_2O_3, Na_2O, K_2O and H_2O increase with depth and
Contents of the CaO, MgO, MnO and I.L. decrease with depth.

CONCLUSION

With the X-ray method there were investigated numerous samples from the layers of the ceramic, brick and substratum clays, and also collective composites from the ore deposit "Srednja strana" – Novi Bečej.

There were identified mineral compositions of the entire sample (> 5μm), and also of the clay component (< 5μm).

Results of the investigations which were obtained with the X-ray diffraction method were compared with the results of the chemical and grain-size investigations.

At basis of the results of these laboratory investigations which were represented at Tables 1-11 it can be made several conclusions about variation of the mineralogical, chemical and grain-size composition, which are primary as the result of the conditions of their genesis (I l i ć, 2003).

At that sense most characteristic is that carbonate content decrease from surface to depth, while content of the clay minerals and feldspars increase.

From mutually ratio of the clay minerals and feldspars it can be seen that in the ceramic and brick clay layers clay minerals are with two, and even with three times more content than feldspars, while in the substratum clay layer they are of approximative contents.

All of the investigations indicate that mineralogical, chemical and grain-size compositions of the brick clays and collective composite samples are favorable than compositions of the ceramic clays.

Also, from the represented results it can be seen that the results from the X-ray and chemical investigations are in very good agreement, while with the grain-size they manifested something bigger disagreement.

Namely:

Where with the X-ray method were established higher carbonate contents, there are higher contents of the CaO, MgO and I.L. which were obtained by the chemical analysis.

Where with the X-ray method clay minerals and feldspars are established with higher contents, there are higher contents of the SiO_2, Al_2O_3, Na_2O and K_2O which were obtained by the chemical analysis.

If the clay minerals are with more content than feldspars and carbonates, there are higher contents of the H_2O.

Where with the X-ray investigations were established higher contents of the clay minerals, that is also confirmed with the grain-size investigations. However, that content of the clay component at the grain-size investigations is lesser than the X-ray and chemical investigations indicate.

In our vocational literature there is a considerable lack of representing the datas at such manner, and especially of identified mineral, chemical and grain-size compositions of the individual layers, and also of the entire ore deposit.

Also, rarity is to see the comparative results which were obtained by several different methods.

Because of that, we hope that represented results will contribute to the better understanding of the geology and mineralogy from this area.

Recenzent: Dr. Mihovil Logar, redovan profesor

REFERENCES

1.Bailey and Tyler, 1960: JCPDS 13-0003, Chlorite, Econ. Geol., 55, 150.

2.Blanchard, F., 1991: JCPDS 43-0697, Calcite, magnesian, Dept. of Geology, Univ. of Florida, Gainesville, Florida, USA, ICDD Grant-In-Aid.

3.Borg and Smith 1969, JCPDS 22-0687, Microcline, Am. Mineral., 54, 163.

4.Brindley, G., 1977: JCPDS 29-1488, Kaolinite, Penn State Univ., University Park, PA, USA, ICDD Grant-In-Aid.

5.Brindley, G., 1977: JCPDS 29-1498, Montmorillonite, Penn State Univ., University Park, PA, USA, ICDD Grant-In-Aid.

6.Ilić, B., 2003: Elaborat o rezervama keramičkih i opekarskih glina u ležištu "Srednja strana", FSD Geoinstituta, Belgrade. (in Serbian)

7.Keller, L. and McCarthy, G., 1985: JCPDS 36-0426, Dolomite, North Dakota State Univ., Fargo, ND, USA, ICDD Grant-In-Aid.

8.Kern, A. and Eysel, W., 1993: JCPDS 46-1045, Quartz, Mineralogisch-Petrograph. Inst., Univ. Heidelberg, Germany, ICDD Grant-In-Aid.

9.Mukherjee, 1963: JCPDS 16-0613, Vermiculite, Clay Miner. Bull., 5, 194.

10.Sanc, I., 1990: JCPDS 41-1486, Anorthite, Polytechna, Foreign Trade Corporation, Panska, Czechoslovakia, ICDD Grant-In-Aid.

11.Shimoda, S., 1970: JCPDS 43-0685, Illite, Clays, Clay Miner., 18, 269.

12.Smith 1956: JCPDS 10-0393, Albite, Mineral. Mag., 31, 47.

13.Swanson, H. E. and Fuyat, R. K., 1953: JCPDS 05-0586, Calcite, Natl. Bur. Stand. (U.S.), Circ. 539, II, p. 51.

14.Visser, J., 1966: JCPDS 31-0966, Orthoclase, Technisch Physische Dienst, Delft, The Netherlands, ICDD Grant-In-Aid.